THE NAVIGATOR

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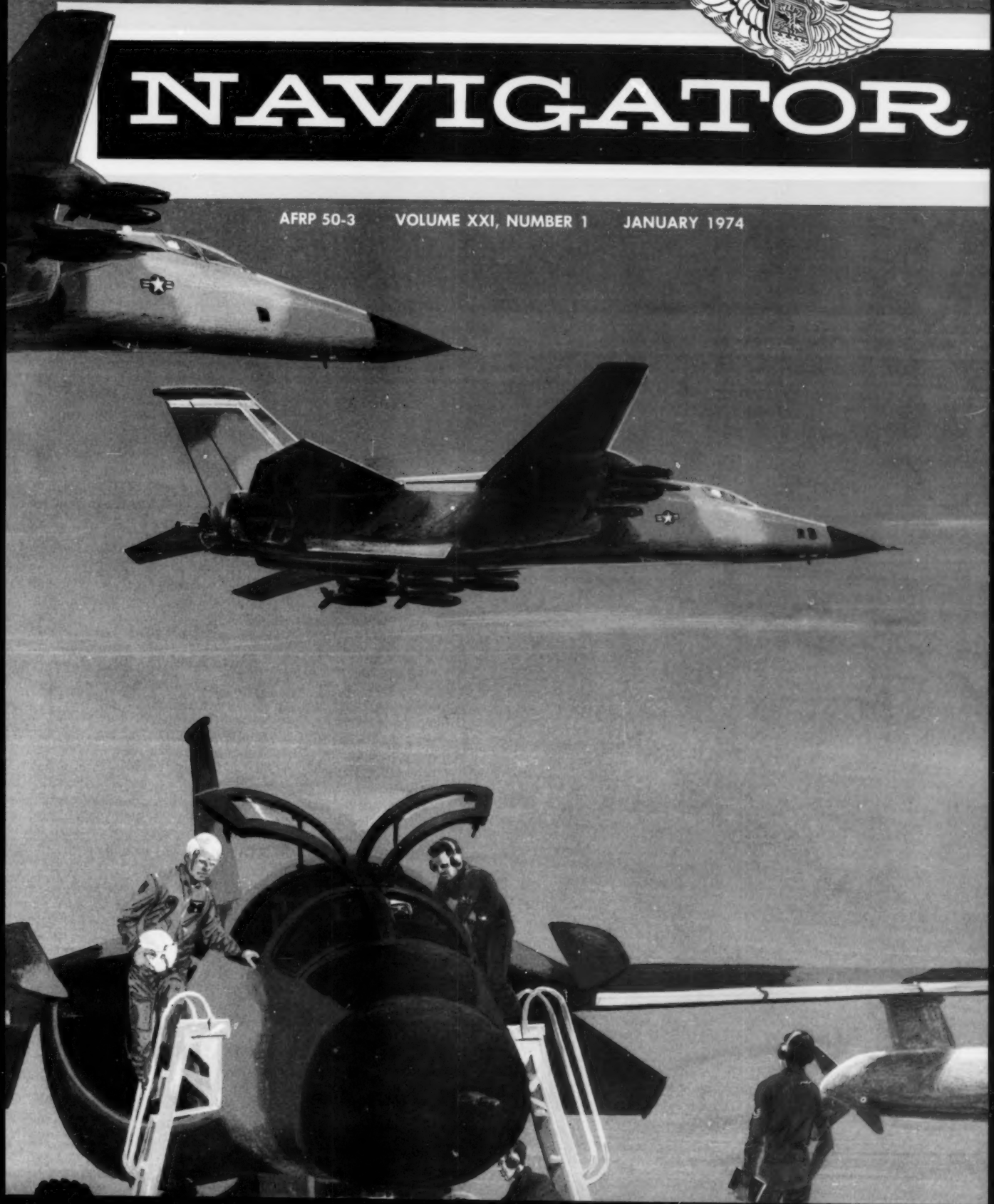
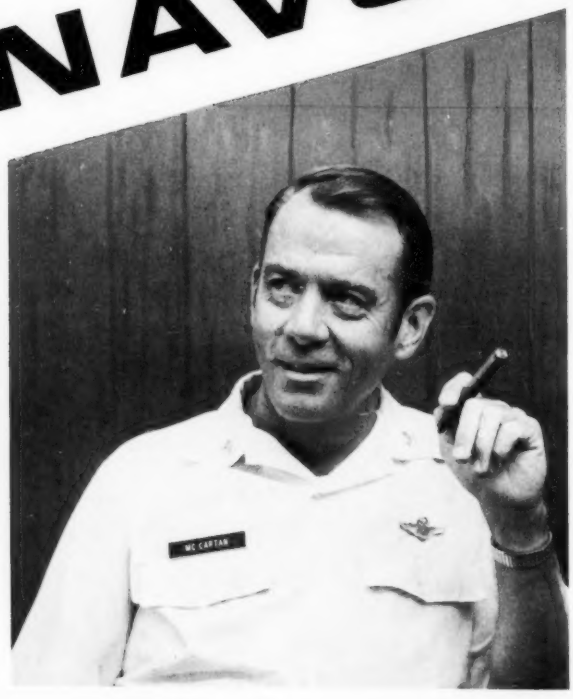


NAVS OF NOTE

COLONEL JOHN S. COADY, JR.

Colonel John S. Coady, Jr. is the Chief of the Bombing-Navigation Division, Operations and Training Directorate, Headquarters, SAC, Offutt AFB. Popularly known as SAC's "CINCNAV," Colonel Coady staffs for the Operations Deputate matters related to manned strategic bombing, navigation, electronic warfare and navigator professional development. He is central manager for SAC navigator training, and is responsible for route development, radar bomb scoring and ground-directed bombing, training manuals and standards. He has made significant changes to the SAC requirements for ATC courses, which provided an impetus for the development of no-fly programs for both Navigator-Bombardier Training and Electronic Warfare Training. Due to his efforts, training for the FB-111 and B-52 radar navigator has been opened to new Undergraduate Navigator Training graduates, and career progression within SAC has been widely expanded. Since receiving his wings in 1951, Colonel Coady has flown as tanker navigator (KB-29); navigator, photo-navigator, and radar-navigator (RB-36); radar-bombardier (B-36); and radar-navigator (B-52). He has served as the Bomb Nav Branch Chief and Assistant Deputy Commander for Operations in the 28th Bombardment Wing, Ellsworth AFB, SD, before moving to Headquarters, SAC, in January 1972. Colonel Coady has served 17 years in crew duty, amassing a total of 7250 flying hours, including 5000 in the B-52D. He has accumulated 100 combat missions in the B-52 during four temporary duty tours in Southeast Asia. With SAC receiving 50% of the total USAF navigator production, Colonel Coady's efforts for improving navigator motivation, progression, and retention are impacting navigators throughout the Air Force.



COLONEL ROBERT O. McCARTAN

Colonel Robert O. McCartan is Deputy Commander for Navigator Training, 323d Flying Training Wing, Mather AFB, where he is directly in charge of all USAF navigator training, including Undergraduate Navigator Training, Navigator-Bombardier Training, Electronic Warfare Training, and several navigator staff courses. Colonel McCartan was graduated in 1952 from Arizona State University, commissioned through AFROTC, and received his navigator wings in June 1954. He was among the handful of young Air Force lieutenants to enter the early stages of SAC's B-47 program. During his tenure in the B-47 program, he was a member of a SAC select crew which won awards for outstanding performance in two all-SAC bombing-navigation competitions. From 1963 to 1966, he supervised the cadet Navigation Indoctrination program at the Air Force Academy and served as a staff officer for the development of an Aerospace Education Center at the Academy. Colonel McCartan earned a master's degree at the University of Denver, attended the Armed Forces Staff College, and in 1967, joined the 355th Bomb Wing as a squadron staff navigator flying EB-66s. During this tour of duty, he flew 161 combat missions, 30 over the Hanoi area. Colonel McCartan then served for four years with the Air Staff at Headquarters, USAF. With duty in the Flying Training Division, Directorate of Personnel Programs, under the Deputy Chief of Staff for Personnel, he was responsible for all navigator, electronic warfare, and survival training in the Air Force. During that time, he was instrumental in "selling" the concept of a new Undergraduate Navigator Training System (UNTS) to the Congress, the Office of the Secretary of Defense and the Air Staff. UNTS, soon a reality, incorporates the T-43 aircraft and the T-45 simulator. Colonel McCartan was named to his present position in October 1972.

FROM THE EDITOR

OUTSTANDING...

Have you seriously considered what one by-line in THE NAVIGATOR can mean to your career? Check the form for Officer Effectiveness Reports. Think what a published article will mean for your grade in Knowledge of Duties... Leadership Characteristics... Judgment... Writing Ability. Every man has a story to tell, every unit has a story behind it. Why not tell your story through THE NAVIGATOR? Send copy through your headquarters to:

323 FTW/DNPM
Editor, THE NAVIGATOR
Mather AFB CA 95655

ANNUAL SURVEY...

Once a year, shortly before a contract is negotiated with a commercial printer, we are required to submit our justification for continued publication. Since THE NAVIGATOR is the only publication affording a free interchange of ideas and promoting a better understanding and utilization of Air Force navigator skills and techniques, justification has been easy. The last justification was based, in a large measure, on the overwhelming response of our readers during our last survey. Well, it's survey time again and you will shortly receive this year's edition. Please complete it carefully, stating *your* desires. It's *your* magazine and we want to please *you.*

WHERE ARE YOU???

Many of the navs I've spoken to lately have expressed a desire to get in touch with their nav school classmates. If this idea appeals to you, please forward a card or letter with your name, rank, SSAN, duty title, address, Autovon number and your class number to THE NAVIGATOR. THE NAVIGATOR will act as the central point to accumulate the information, arrange it by class number, and forward a complete-as-possible list to all participants by June 1974. Five minutes of your time will help get this project on the road. Come on, class 60-21, where are you?

CALLING ALL PACKRATS!!!

Our staff is attempting to compile a complete set of THE NAVIGATOR. At the present time, we are missing only the two issues of Summer 1953 and July 1955, when it was called THE AIRCRAFT OBSERVER. If any reader possesses either of these issues, we would be grateful if you would donate it to us for a historical display or at least let us reproduce your copy.

TO THE EDITOR

Dear Editor:

In the Winter 1966 issue of THE NAVIGATOR magazine, there appeared an Emergency Air Almanac table. This table had information through 1975. Could you give us information on updating the table through 1980? Would you permit us to reproduce this table? Would it be possible to reproduce material without prior approval if the agency is an Air Force organization?

Reuel T. Werner, Lt Col, USAF
Chief, Offensive Systems Branch
92nd Bomb Wing
Fairchild AFB, Washington

Thanks for your interest in THE NAVIGATOR. You may certainly reproduce the "Emergency Air Almanac" article published in the Winter 1966 issue, however we request notification prior to reprinting or otherwise reproducing other articles. Several articles that were published in the magazine were printed from sources outside the Air Force and would need further permission from that source prior to additional publication. In addition, we may be able to update or correct articles that have been published, based on new information or Letters to the Editor.

For your information, the "Emergency Air Almanac" was originally published in the May 1961 NAVIGATOR and was updated for the 1966 issue. Your request on the method of updating the charts through 1980 caught me by surprise, since I did not know how the charts were put together originally. With a little research, however, I figured it out and so I thank you for sparking my curiousity.

The charts were derived with the help of H.O. Pub. No. 9, "American Practical Navigator," published by the U.S. Naval Oceanographic Office. Our copy was printed by the Government Printing Office in 1966. Reference Appendix X, Long Term Almanac, pages 1160-1161 and the chart on page 1164. You will note that charts b and c in our article are constant and do not require updating. The charts for the years 1967-1975 are also contained on page 320, Volume I of the H.O. 249 tables.

If you intend to update the charts published in 1966, we would appreciate a copy for possible inclusion in THE NAVIGATOR.

Ed.

Dear Editor:

We would like permission to reproduce several copies of an article in your magazine, Volume XX, No. 1, 1973. The article is entitled "On-Course Rendezvous" by Captain John C. Hogwood. I wish to send these copies to the wing-level staff navigators within our numbered Air Force for their review and opinions. This method may improve our on-course rendezvous procedures within 8th Air Force.

8th Air Force/DON
APO San Francisco 96334

You bet! Anytime our magazine can be useful in promoting good nav procedures or techniques, we are pleased to help.

Ed.

THE NAVIGATOR

Volume XXI, Number 1 January 1974

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AIR TRAINING COMMAND
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The purpose of THE NAVIGATOR, established by Headquarters, USAF, in 1953 (original title, AIRCRAFT OBSERVER) is to convey to navigator-rated personnel information and ideas of professional and general interest, thereby promoting a better understanding and utilization of navigational knowledge, skills, and techniques.

Guest cartoonists for this issue are Captain Gregory J. SHEBEST, 27th Tactical Fighter Squadron, MacDill AFB, Florida, and Lieutenant Stanley R. SPENCER, 908th Air Refueling Squadron, Kincheloe AFB, Michigan.

the future is NOW!

Captain Donald M. BILLICK
452d Flying Training Squadron
Mather AFB, California

In October 1973, the formal flight testing and evaluation program for the T-43 was completed. The acceptance of the T-43 into the Air Force inventory marks the beginning of a new phase in navigator training. The new program is the Undergraduate Navigator Training System (UNTS) which combines a sophisticated simulator (the T-45) with the T-43 aircraft. Because they will be exposed to avionics and techniques that previous generations had to learn in the field, graduates of this new program will be better prepared to take their places in the high speed, multi-mission jet aircraft of the future. They will go beyond the classical role of the navigator to become "systems managers."

The conception of the T-43 and UNTS can really be traced to the time when our pilot counterparts started flying jet trainers. Many felt that the training available in the T-29C and the current generation of ground simulators was not compatible with the training received by student pilots in T-37 and T-38 aircraft. Our graduates had a lot of "catching up" to do once they left the school. UNTS and the T-43 will allow the navigator to be at least as well prepared for his initial flying assignment as the fledgling pilot!

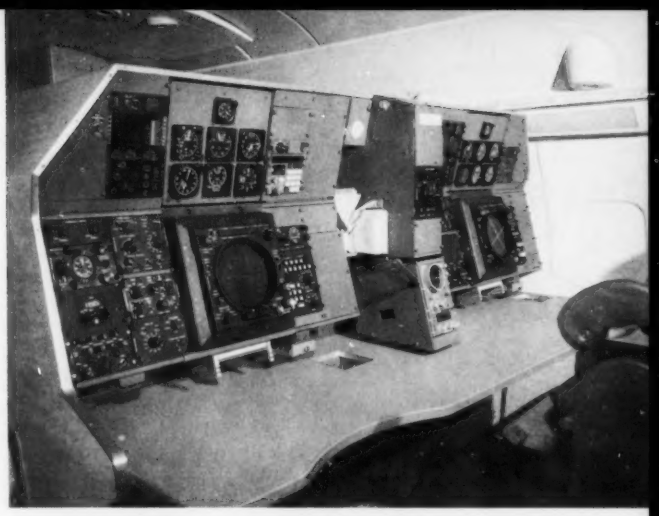
The T-43 also represents a change in the amount of involvement of a using command in the initial test program of a new weapon system. This change in AFR 80-14, governing test programs, has allowed those personnel in the initial cadre (an experienced group of 30 navigator instructors and 10 pilots at Mather) to instigate major changes before the airplane began flying the line. In the past, using commands were more or less obligated to perform the task with the end product. "They" designed it, but "we" had to use it. Under the new AFR 80-14, using commands take a greater role in designing aircraft to suit the mission, rather than re-designing the mission to suit the aircraft. Hopefully, by the time the first student walks up the stairs, all of the problems that are inherent in any new airplane will have been resolved. The result, obviously, is going to be better

student training and an aircraft better suited to the mission.

The T-43 is a twin-engined, swept wing, high speed, high altitude aircraft derived from the Boeing 737-200 advanced airframe. The aircraft has two entrance doors (front and rear) and an electrically operated airstair which retracts internally into the electronic equipment storage area. Each entrance door is equipped with a commercial-type emergency escape slide which can be set to inflate automatically with door opening. Two lighted cargo storage areas provide ample room for baggage for the entire crew. The main gear retracts into an open gear well which can be viewed from inside the aircraft to visually check gear status. The basic airframe has been modified with the addition of an auxiliary fuel tank, contractually assuring cruise range in excess of 2700nm. Flight tests have already demonstrated ranges of approximately 2750nm (at cruise, approximately 6.7 hours) with a 40 minute reserve. Modifications to the electrical system have been made to support the increased requirements of the avionics package in the training compartment. A commercial lavatory has put to rest the oft-heard "honey bucket" war stories of the T-29 era. The interior of the training compartment is equipped with ceiling and cove lighting similar to those of airliners. Noise abatement wall paneling permits normal voice levels to be used in flight. Personnel, flying the T-43 for the first time, are amazed that a military line aircraft could be so quiet.

The airplane has proven to be quite stable, demonstrating little sensation of flight at high level. The T-43 is structurally limited to .84 Mach, 35,000 feet, and 350 KIAS at low level. Normal cruise parameters established during the test program have been a high level cruise of .74 Mach, altitudes of 29,000 and 33,000 feet (based on published altitude), and from 220 KIAS to 330 KIAS at low level.

Looking aft from the master student position. Poles are for sliding celestial stands. Box in right of picture holds life raft.



Side by side seating enables the students to share the Tacan and Loran equipment.

The aircraft has a self-contained auxiliary power unit which supports both the electrical load and an air conditioning unit. The nature of the avionics requires that cabin temperatures be kept well below the "uncomfortable" temperature levels so that noon preflights on hot August days and long delays at the run-up area are no longer "sweatbaths."

The training compartment is functionally arranged into three complexes. Each complex has four student positions and one instructor position. The student seats are arranged side-by-side at a console with two consoles per complex. The instructor's console is located between the two student consoles. The instructor's seat is mounted on rails which permit the seat to be positioned between the two students at a console.

Additional seating is provided for minimum proficiency fliers but these positions do not have navigational equipment and will probably be used for flight surgeons, stan/eval, and other observers. Two maximum proficiency stations are also provided. These have limited avionics and will be used for crew members flying for proficiency only and not directly involved with the student training portion of the mission.

The master student position is the only position that has a complete avionics panel. Other student positions have a partial panel with decals in those positions where the avionics would otherwise be, providing continuity between the simulator and the airplane, and familiarizing the student with equipment location to ease transition from student positions to the master position.

The equipment available to the student is impressive indeed and is representative of the avionics available in today's high speed aircraft. The AN/AIC-18 interphone system has four separate interphone channels. Each student complex and the proficiency stations have their own interphone channel, and a group interphone connects all stations within the training compartment.

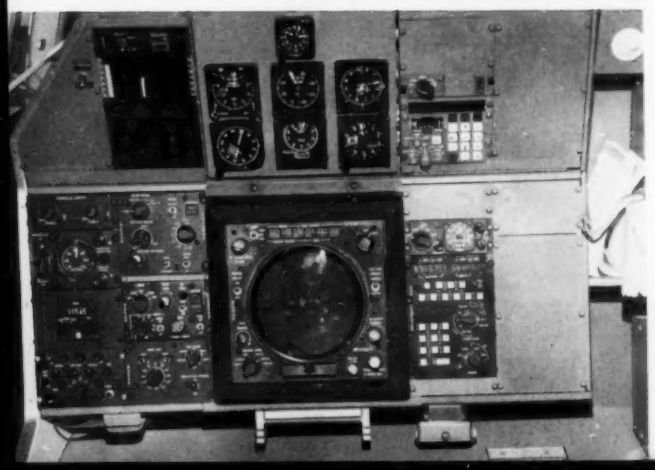
The pilots have the ability to monitor group interphone transmissions, but have no capability to transmit on this channel. The main interphone channel connects the training compartment with the cockpit. The additional feature of hot microphone and hot listen switches allows more selective segregation of students and instructors. The interphone system also allows selective monitoring of communications radios and navaids (TACAN, VHF NAV, ADF). Each position has the ability to transmit on UHF by selecting the U-1 position on the wafer selector switch.

There are 14 VOR systems on the airplane. All student positions and maximum proficiency stations have their own VOR control head. The multiple control heads are tied by a multi-coupler to one antenna located in the vertical stabilizer. Flight tests have shown that all sets can be tuned to different frequencies without any resulting interference. Each student complex has its own TACAN system. All students within the complex have readouts from the system. A control head is provided for each student console in the complex, with a transfer switch provided to take control of channel selection. All students are provided bearing and DME to whichever station is selected by either control head. The control heads are standard government-furnished TACAN control heads. Maximum proficiency stations are provided readouts from TACAN channels selected by the cockpit.

Radar pressurization is furnished by the familiar ASQ-70. The unique feature of the pressurization system is the size of the waveguide—it's approximately 12 feet long. A large accumulator bottle has been incorporated to maintain system pressure.

The APQ-122-(V)7 is a new generation radar system. It is an X-band, long range radar with mapping, weather and beacon operating modes. The system has two back-to-back mounted antennas (fan beam and pencil beam) which are gyro-stabilized throughout the normal flight envelope. The radar can be selectively tuned in 50 MHz increments from 9100 to 9500 MHz. The radar has fast time constant and sensitivity time constant features as well as an iso-echo feature.

Master Student Station. Equipment to train tomorrow's navigator.



The mapping mode provides ranges up to 240nm with individual full scope range settings of 8nm, 3-30nm, 50nm, 100nm, and 240nm. Range marks can be selected for 1nm, 5nm, 10nm, 20nm, and 30nm. In the 30nm range setting, a variable range adjustment allows scope expansion from 3 to 30nm full scope display. Displaying 3nm on a full seven inch scope provides radar scope interpretation training beyond any previous training radar. In the mapping mode of operation, the set has a PRF of 2000 Hz (0.3 microseconds pulsewidth) in the range settings of 3-30nm and 8nm, 1000 Hz (0.6 microseconds pulsewidth) in the 50nm range and 250Hz (4.0 microseconds pulsewidth) when in the 100 and 240nm range setting. Repeater scopes can be operated at the same or higher PRF as the master. This means the master may be operated at 50nm range while the repeaters may be operated at 3-30nm ranges. A range delay function allows selective full scope expansion of targets in the vicinity of an electronic cursor. When in the range delay function, the electronic cursor is centered on the scope and the area on either side of the cursor can be made to display 1.5 to 15nm. The range delay function is operative in the 50nm or greater ranges.

The weather function operates on a fixed frequency of 250 Hz. It is range-limited to 150nm, and possesses the same range flexibility as the mapping function. An iso-echo feature allows selective display of the weather on the scope. The scope will display weather of equal or greater intensities than that selected on the panel. Adjustable settings of light, moderate, heavy, and excess are available. The display is a reverse display; areas to be avoided appear as no-show areas.

The beacon function, which also possesses the same range flexibility as the other functions, operates on a fixed frequency of 250Hz with a 2.35 microsecond pulsewidth. The range delay feature used in conjunction with the beacon allows expansion of the coded displays for greater ease in reading the code. Flight test crews have picked up coded beacons in excess of 195nm from X-band transmitters.

The APQ-122-(V)7 has the functions of high sweep rate (45rpm) or low sweep rate (12rpm), and sector. Each repeater scope operator has the ability to offset or center the sector when the master position operator selects sector operation. The sector can be manually positioned, or positioned around the electronic cursors of the master scope. The sector can be adjusted from 30 to 300 degrees. Realistically, the sector is limited to approximately 240 degrees by the location of the antenna and the antenna shield assembly.

The antenna system can be locked to a constant boresight reference or can be gyro-stabilized through the

normal flight envelope. The tilt of the selected antenna can be adjusted from plus 10 degrees to minus 15 degrees.

The radar has heading stabilization modes of North Up display, Heading Up display (references to the nose of the aircraft) and Track Up display. All scopes are limited to the stabilization mode selected by the master scope operator. The scopes have adjustable manual bearing cursors and offset cursors. The radar scope is linked to the navigational computer system in the operation of the electronic cursor. Once positioned by the "joy stick," the cursor will track a target using tracking information from the navigational computer system. Additionally, the navigational computer system can be programmed with target information and its position can be updated by means of positioning the electronic cursors. The cursors can be slewed in a high slew rate and a slow slew rate (.54 inches per second and .27 inches per second, respectively).

The radar system will allow a greater amount of flexibility in the student training environment by teaching the operator to develop his own tuning techniques. The master scope has control of the frequency, tilt, beam pattern and master receiver gain, but repeater scopes have their own video, sweep intensity, range selection (within limits) and scope presentation.

Each student position has its own AN/ASN-112 Navigation Computer System (NCS), a basic dead reckoning computer. The computer receives inputs from the LTN-51 Inertial Navigation System (INS), doppler, air data computer, and compass systems. The NCS provides the student with a basic position, wind, drift angle, groundspeed, and true heading, either from the INS or doppler, as selected by the operator. The operator can manually insert wind in the event the doppler inputs appear unreliable, or he can elect to continue using doppler inputs to derive the displayed wind.

The computer is tied to the radar such that prepositioned electronic cursors can be used to automatically update the NCS. The operator is required to program coordinates and clearance altitude information for auto-update of the NCS position. The electronic cursors will track a target, once positioned, using NCS tracking information.

The master student position has functional control of the INS, but repeater positions are able to use INS information to crosscheck other navigational aids.

Each student position is provided heading information from both an attitude heading reference system (AHRS) and a C-9D compass system. The C-9D system is a magnetic compass similar to the J-2 system now used in the T-29C. The readouts are displayed on a Bearing Distance Heading Indicator. The AHRS is similar in appearance and operation to several slaved/DG compass systems used Air Force-wide. The system provides inputs to the familiar V-8 indicator. The master student position has the option of selecting C-9D or AHRS inputs to the NCS and the radar.

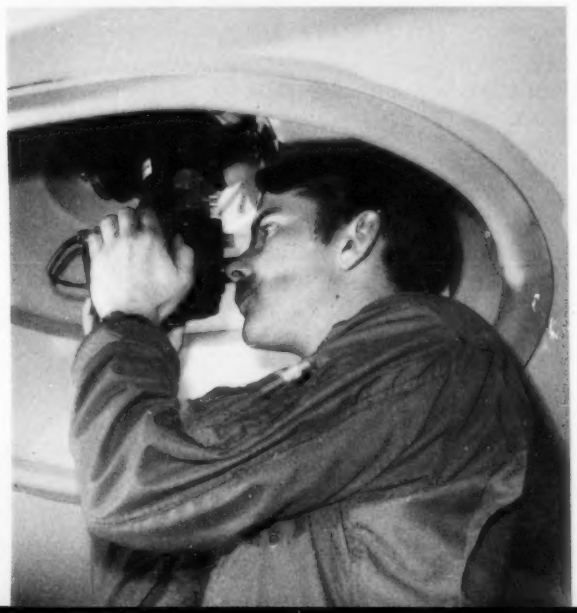
Each student position has a static air temperature gauge which indicates free air temperature. The normal corrections for position and compressibility are already applied by the air data computer.

The altimeter is an electrical-mechanical instrument driven by the air data computer. As a result, hysteresis eror is absent. Flight test data indicate that only one reading is necessary for pressure pattern work. You can also save wear and tear on the knuckles by not having to tap the instrument between readings.

The student is provided a high range radar altimeter (HRRA). The HRRA provides a single pointer, counter drum readout. Operation and built-in test control is available at the master student position with repeater positions having ON-OFF control of their indicators.

The INS is a commercial Litton LTN-51 with a unique software program. The INS is intended to function as a training tool rather than flight-essential avionics and is not, therefore, tied into any of the basic aircraft control systems. The digital computer of the inertial navigation unit is, however, data-linked to the NCS computer to provide INS present position, drift angle, groundspeed, and true heading to NCS panels at each student position. Additional readouts available at the master position include track, cross track error (the distance off course measured perpendicularly), cross track angle error (the difference between planned and actual courses), distance to the next waypoint, time (based upon current groundspeed) to the next waypoint, wind and desired track. The system has the capability of reading out malfunction codes which provide the student valuable training during inflight analysis of possible problem areas and recommended solutions.

Shooting celestial is about the only similarity between the T-29 and the T-43.



Up to nine waypoints of a given route can be programmed into the INS at a given time. The system will automatically re-establish waypoint reference as the mission progresses, or it can be set to require manual re-establishment of waypoints by the master student. Additionally, the operator can selectively re-adjust waypoint sequencing and display information relative to any of the waypoints previously programmed. The system will trigger an alert light when the aircraft is within two minutes of the next waypoint.

There are six ARN-109 Loran C sets on the aircraft. Each student console has a set centrally mounted on a swivel bracket, allowing each student a direct monitor capability. The system operates at 100 KHz with a maximum ground wave range of approximately 1200nm over water, 900nm over land. The sky wave range is approximately 2500nm. Fixing accuracy is listed as 200-400 yards at optimum distance and approximately ½ to 1nm at ranges of 1000nm.

All six sets are connected to a single belly-mounted antenna via a multi-coupler. The system will automatically track, with warning lights indicating the possibility of inaccurate readings. Lock-on to two slave stations of the same chain can be maintained with time-delay readouts being alternately displayed digitally every two seconds or individually displayed. The system will conduct its own wide band search for a signal once the initial station is set up on the control panel. Once locked on, the set can be switched to track and will automatically track the signals. A video presentation can be used to initially locate receivable signals, or an indexing scale can be used.

Flight test data indicate that signal acquisition requires about 5 to 7 minutes once within range of a station, and that the system maintains stable lock-ons in adverse weather and throughout the normal flight envelope even when ranges in excess of 1000nm, with ground waves, are involved. The system has a filtering function to permit selective isolation of electromagnetic interference.

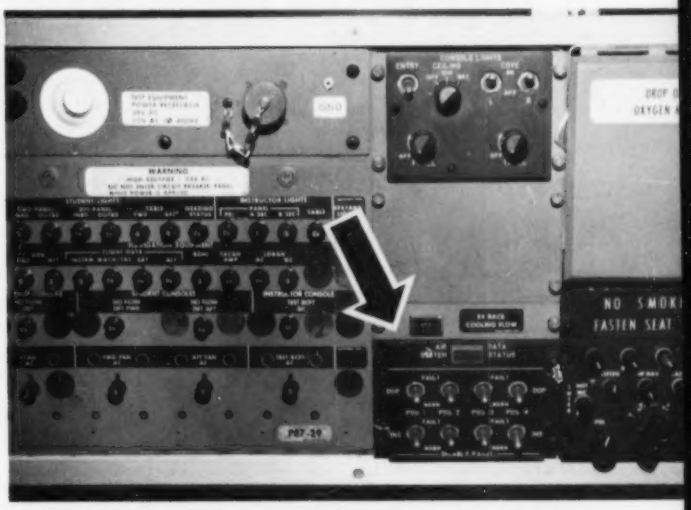
The APN-153(V) doppler system is installed at the master student's position. Information from the doppler is supplied to the NCS computer to provide drift angle and groundspeed information to each student position. The doppler information is used by the NCS computer to derive a wind which is also displayed at student positions on their NCS panels. The APN-153 has proven to be very similar in operating characteristics to the doppler in the C-141.

There are five sextant stands on the airplane. The sextant stands are circular platforms attached to a support pole. Each stand can be adjusted with one hand to the height of the user. The standard D-2 sextant arrangement has been installed, with an adjustable light in each "dome."

The seats on the aircraft are adjustable in all three axes. They contour to the user after approximately 30 minutes of use. They have adjustable arm rests, self-locking inertial reels, and a standard lap belt arrangement. Each position is lighted by commercial white lights mounted in the ceiling and each is provided a commercial pop-out oxygen mask which will automatically deploy when the cabin altitude reaches 14,000 feet MSL. Standard push-button microphone cords are provided, along with a floor-mounted switch for each position.

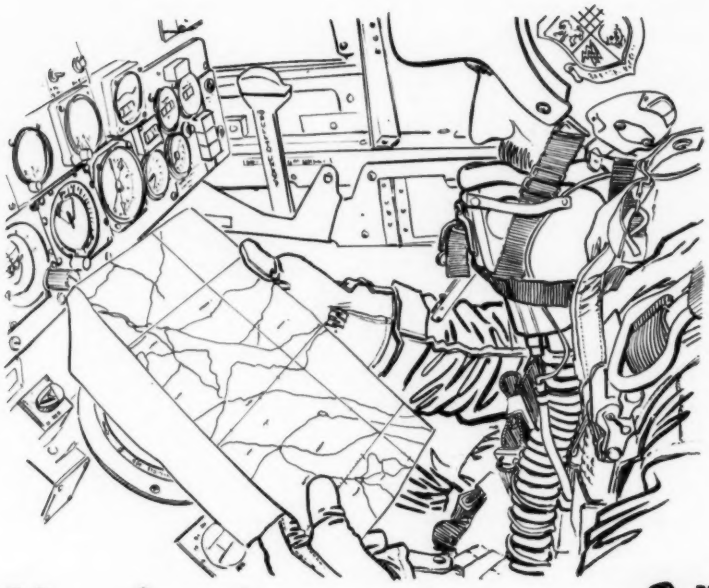
Each student-pair console has a storage area for FLIP publications, Air Almanacs, and celestial volumes. It is amazing how light your nav bag becomes when all of these pubs are stored in the aircraft.

The three instructors' positions are provided fault switches that allow selective failing of certain pieces of equipment at the student's panel. This allows the instructor to shape the mission and, of course, it allows them to force the student to use alternate avionics. A student will not be able to simply sit back and let the NCS or INS do the work for him.



Note the Disable Panel installed in the instructor's position. (arrow)

The T-43 will present a tremendous challenge to both students and instructors. It is going to take a lot of hard work by the students if they expect to master this myriad of sophisticated equipment in the short time available in the program. Instructors are going to have to be better teachers and better navigators to handle the questions presented by our new generation of students. The small and sometimes overlooked errors at 180K seem to take on greater emphasis at 35,000 feet and .74 Mach. The students of the future probably won't even appreciate the war stories that begin with; "You guys have it easy now. In the T-29, things were a lot different."



"Navigator, or.....?"

Colonel Robert O. McCARTAN
Deputy Commander for Navigator Training
323d Flying Training Wing
Mather AFB, California

Editor's Note: The following article has been taken from an address by Colonel Robert O. McCartan during the formal Air Force acceptance of the first T-43 on 28 September 1973.

You've already heard many, many words today about the significance of this milestone date. You've heard how cost effective the T-43 will be, how it will reduce training time, and how the new system will revolutionize U.S. Air Force navigator training. All of this is very true, so I would like to address my comments this morning to another subject; that is, the new role for the Air Force navigator and why we needed this new training system to prepare him for this new role.

I would like to start out by telling you what a navigator is and how he fits into his new role. Everybody knows what a pilot is and what he does. He's the man with the stick and rudder; he gets the airplane off the ground and back on the ground. But when we talk about navigators, there's an old stereotype picture of what a navigator is. He's that fellow who goes across the ocean with a sextant in his hand, going from Point A to Point B. And this false stereotype is the one that gets us into trouble. Let me cite an example of what I'm talking about. When I first went to the Pentagon in 1968, one of the first tasks that I was given was to sell this 150 million dollar navigator training equipment program to Congress. The program had just been dropped from the Senate Armed Services Committee package in March 1969. The way I tackled the problem was to gather all the information I could on the committee's testimony from the previous year. This congressional testimony reflects that one senator who led the strongest opposition to the navigator training system is quoted in the congressional committee hearings as saying, "I flew all during the war (WW II)—as a pilot—without benefit of a navigator, though sometimes I wished I had one, and once when I did have one, I wished I had not." Further committee hearings centered on the rationale of why we needed navigators in this day and age with the sophisticated avionics equipment we have, such as inertial, doppler, Loran, and the rest. Commercial airlines don't use navigators as such; why is the Air Force continuing to train navigators? Well, it became very clear at that point that some members of the congressional committee had a misconception of the mission and role of the Air Force navigator. Although we still call ourselves navigators, the job has changed. So we put a briefing together, and keyed in on the senator's remarks. We went over to the hill and briefed on the new role of the navigator in the modern Air Force.

We told of the decision, in 1966, to place navigators in the back seat of the F-4 and the RF-4 fighter, where previously there had been only pilots. These positions were designed for a pilot—with full pilot controls. About that same time, the decision was made to put navigators in the right seat of the F-111. These major changes were made to provide these weapon systems with a more effective combat capability. From these changes evolved the weapon systems officer and flight systems officer concept. This new breed of navigator is responsible for the operation of *complicated* bombing and missile launch systems in the B-52 and the FB-111/F-111 and the F-4. He also manages *sophisticated*

electronic warfare systems to seek out, deceive, and sometimes, destroy the enemy in such aircraft as the RC-135 reconnaissance aircraft, the EB-66 electronic warfare airplane and the F-105 Wild Weasel. He directs and manages gun-laying equipment, using *sophisticated sensors*, such as infrared and low light level TV in aircraft such as the AC-130 and the AC-119 gunships. He operates all-weather air delivery systems in the AC-130 and the AC-119 gunships. He operates the all-weather air delivery systems in the C-141, the C-130, and the C-5 which give these aircraft the capability to go in during all types of weather—and at night—with pinpoint drops to besieged areas. The new navigator and weapon systems officer operates sophisticated reconnaissance systems in the RF-4 photo recce birds. In this aircraft, he is sometimes called a "photographer." He operates highly complex equipment in the SR-71, our high altitude reconnaissance aircraft. In Vietnam, he picked up a new and dramatic role—that of air-to-air combat. As a result of many Vietnam air battles, the navigator has established himself as an expert in the air-to-air fighter intercept role. To highlight this point, of the three fighter aces who have emerged from Vietnam, two are navigators; only one is a pilot. So, you can see the nav is a gent who turns the airplane into a weapons system. We could call him a weapon systems officer or a flight systems officer because he operates a myriad of equipment such as infrared, lasers, high resolution radar, doppler, inertial, digital computers, low light level TV, to name a few, and he does this in over 50 types and series of aircraft.

As you can see, the role of the navigator today is unlike the role of the senator's World War II nav. The demands of the Air Force navigator are no longer centered around a pair of dividers, a plotter, and a sextant. Innovations in already sophisticated equipment, plus the rising complexity of Air Force missions, have expanded his role. Today's navigator has become an airborne systems manager. Modern technology requires not only that he place the aircraft and weapon system on target at a precise moment and point in space, but that he also apply strategic and defensive electronic warfare skills. Where we used to measure accuracy in miles, we now measure in feet. Where we used to speak of plotters and dividers as the navigator's tools, we now speak of his management of sophisticated electronic computer systems. To fulfill this new role, a basic navigator trainee, who, by the way, is a college graduate, must receive training that is meaningful and relevant to the multiple tasks he will be required to perform in the operational commands. In fact, rapid evolution of avionics systems obligates the navigator to be a part-time student throughout most of his career.

A navigator's career begins at Mather AFB when he enters the undergraduate navigator training program. Today, all Air Force navigator training, basic and advanced, is concentrated here at this Air Training Command base. All navigator training at one location has produced a pool of navigator expertise heretofore unequalled in the world. This expertise has been channeled into a program that now produces the best trained navigators in the history of aviation. We produce over 1300 navs each year here at Mather. We also train navigators for 18 foreign countries.

In 1970, the all new Undergraduate Navigator Training System was presented to Congress and was approved. Hence, the ball began to roll on the first significant update of navigator training in aviation history. The following year, a contract was awarded to Honeywell for design and construction of the T-45 Digital Ground Simulator, and to Boeing for the T-43 Airborne Navigator Trainer.

Using this new equipment, we will now be able to prepare our navigators to become airborne weapons systems managers, do it in a shorter period of time, and at less cost to the taxpayer.

The new eight-month training program has been designed to utilize the instructional systems approach to training. We don't just have a new airplane and a new simulator, we have a whole new training systems package—and an entirely new concept of training. We put the student into the simulator first where we have training flexibility, since the simulator is not affected by environmental conditions such as weather, time of day, time of year, or availability of airplanes. Although ground simulation can provide flexibility in training at reduced costs when compared to airborne training, it cannot provide the needed training to transition the new navigator student, just out of college, into our high-speed, operational combat aircraft. This job must be shared with the Airborne Trainer, the T-43. In the T-43, the nav student will experience the physiological factors of motion, noise and spatial disorientation. It is in this airborne training where the student will be exposed to the psychological factors of stress, anxiety, and, possibly, fear of the airborne environment which he must experience and control. The T-43 will act as a screening device to identify students who are unable to operate in an airborne environment, as well as provide the opportunity to sharpen to a fine

edge the skills he has acquired in the simulator.

This new program is also unique in another way. For the first time, the student navigator will receive training in a pilot simulator where he will learn the basics of flying. This will enhance his role as a weapon systems officer.

By using this modern training system, we're able to reduce airborne training from 186 hours to 145 hours per student and cut the length of his training from 33 to 28 weeks, thus reducing costs and producing a better qualified systems-oriented navigator for the Air Force.

As you can readily see, the world of navigator training is now undergoing a dynamic renaissance. With this new system, we can create a contemporary punch to weapons delivery, electronic warfare, and systems operator quality never before attainable. The qualitative impact of these forward-looking programs has been needed for a long, long time. We also expect to use them well for years to come to train our projected USAF level of 14,000 plus navigators and train for our advanced systems coming down the pike.

The entire Air Force is enthusiastic about the new program, and, of course, we are eagerly awaiting its full implementation.

Experience Not Required

"But It Helps"

1/Lt Michael E. UECKER
393d Bomb Squadron
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A lieutenant in the FB-111? It won't work! Fresh out of Bomb-Nav Training? He can't do it! Not with the sophisticated systems on that bird!

Despite these opinions, a program for six NBT students to enter FB-111 training was initiated on a test basis. I got to be one of them. And now several combat-ready lieutenants are attesting to the fact that experience in B-52s and/or B-58s is not a necessary prerequisite for the FB-111 (although it would have made assimilation of many of SAC's policies and procedures easier).

After Bomb-Nav school, while our classmates were going through Combat Crew Training School at Castle AFB to become B-52 navs and radar navs, we stayed at Mather AFB to attend FB-111 avionics school. In that three-month course, new FB-111 navs (and during the last three weeks, pilots) were exposed to digital computers and the Mark IIB avionics package which is the heart of the airplane's bomb-nav system. But wait ... almost all recent college grads had used digital computers before, and so they had a jump on logic circuits, Boolean algebra, et cetera, which is common to all digital theory. We found that in some cases the student and instructors were on a nearly equal footing. Score one for the lieutenants (our only area of experience which put us ahead of those who had been out of school before the advent of IBM and its products).

Along with the bomb-nav system, avionics school introduced us to ECM and SRAM, as the FB-111 radar navigator is also the defensive systems operator and missile programmer.

Going from Mather to Plattsburgh AFB, New York, was like going from day to night. Everything learned at Mather was put into storage in the back of the brain as we learned that the right seat meant copilot first and navigator second. Learning flight controls, pneudraulics, environmental systems, engines, fuel, and all the other flight systems took up the first two months of CCTS and meant learning the Dash-1 at least as well as the pilots. For a while it seemed like the guy in the right seat was wearing the wrong wings! But since all the other navs with B-52 and B-58 experience had to learn to be copilots too, we could take comfort in knowing that we were all in the same boat. Slowly

one learns that it really *is* possible to be a jack-of-all-trades in this super swing-wing bomber. Adjusting to fuel system malfunctions and reacting to hydraulic failures become as much a part of coping with one's job as computer faults and loss of radar.

The Initial Qualification Check in the FB-111 simulator, considered to be the first big hurdle, is followed by the fun part—flying. Over six months have elapsed since the first day of avionics school back at Mather before the nav goes for his first ride. The checklists that ran so smoothly in the simulator seem to take so long in the aircraft. One finds that not only does the thrill of flying in a supersonic bomber seem to make time go at 30 seconds per minute, but that there are other people in the sky, and still more people on the ground, who also are concerned about your flight. The lieutenant finds that instead of switching off the command radio button as he did in UNT, he now must listen and talk to air traffic control centers, metro stations, bombplots and command posts.

The nav finds that a refueling rendezvous in the air is no different than one in the simulator, just a little more hectic; that a bomb run is twice the work it was in the simulator; and that the aircraft is really a pleasure to fly.

During takeoff roll, copilot is the name of the game due to the coordination with the pilot on engine instruments, fuel, flight instruments and back-up instruments. The nav watches the ADI as the pilot rotates the aircraft on the takeoff role, then switches to the engines, gear, flaps, slats, and wingsweep, as the pilot sequentially cleans up the bird. Only after both afterburners are disengaged does he look back at the right side of the cockpit to crosscheck the computers and assure himself that they are operating properly . After the climb and level-off checks are accomplished, the nav/copilot turns his attention to the avionics, monitoring and checking to assure all is well. Auto steering insures that, if all is well, the airplane will fly from one tape-loaded destination/target to the next with the crew monitoring the Navigation Display Unit (NDU) to insure that the present position and altitude is correct. During low level, crew coordination is even more important than it is in high altitude cruise, as the pilot crosschecks all headings and altitudes with his right-hand man to insure accurate navigation. Crosstalk between the two is never-ending, as the pilot monitors engines and fuel and backs up the navigator visually while the nav switches from navigation to defensive systems operation, talks to bombplot and sets up for the bomb run.

With the FB-111's TFR system, low level is sporting because the short radar range, coupled with the high speed of the aircraft, makes decision-making a split-second operation. A 90-degree radar sector gives the operator only seconds to decide whether the system is accurate.

After the bomb run, the next chore is an air refueling rendezvous—an operation almost too easy with the lock-on capability of the Attack Radar System. Once on the tanker, the nav again concerns himself primarily with cross-checking instruments and constantly watching where the fuel is going. The aircraft center of gravity (CG) is critical and the knowledge that a landing will be less than 40 minutes after the end of air refueling provides him no time to correct his errors, should he allow too much fuel to go into the wrong places.

Landing, for the nav, is the same as takeoff, except that in addition to monitoring the instruments, the nav must also set up the radar for a back-up Airborne Instrument Landing Approach (similar to, but more accurate than, an ARA). It provides glide slope plus course information. The nav then assures that the airfield is in sight and that all information on hand agrees.

Probably the most difficult part of the whole FB-111 upgrade program is the degraded-system training that is conducted immediately after Combat Crew Training School. During this training, the new nav discovers that DR is only as good as the bomb-nav heading and groundspeed. Degraded-system training involves deselecting certain navigational sensors, INS, astrotracker and/or doppler, and using manual radar fixes, hand-entered computer wind and magnetic variation updates to build an accurate navigation model. This is where the pilot can inflate or destroy the nav's confidence by map reading and pointing out whether or not we're on course. There's nothing worse than thinking you've got it wired, and then hearing the left-seater say, "I don't remember crossing that ridge ahead," at 180 seconds TTG. But every flight in this bird is an education, as more and more different techniques are tried. The job becomes ever more challenging: the more we learn of the nuances of an INS and digital computer complex, the more the nav has to stay on his toes.

The FB-111, having many unique capabilities, is an awesome weapon system, and being a part of the team that makes it one is a tremendous opportunity. But for a guy right out of UNT, it is even more meaningful. It is the fulfillment of a goal and the beginning of a career.

Editor's Note: It was the outstanding performance of the six select NBT students who entered this program that resulted in its becoming permanent policy. FB-111 duty is now available to all USAF navigators, including top UNT students, on a limited basis.

Instant INTERCEPT

Captain Gary C. EICKMEIER
450th Flying Training Squadron
Mather AFB, California

A perplexing problem faced by many navigators is that of intercepting another aircraft at a given point in space, such as the rendezvous between a tanker and receiver. I encountered the intercept problem while assigned as a tanker navigator in Southeast Asia, refueling B-52s over water.

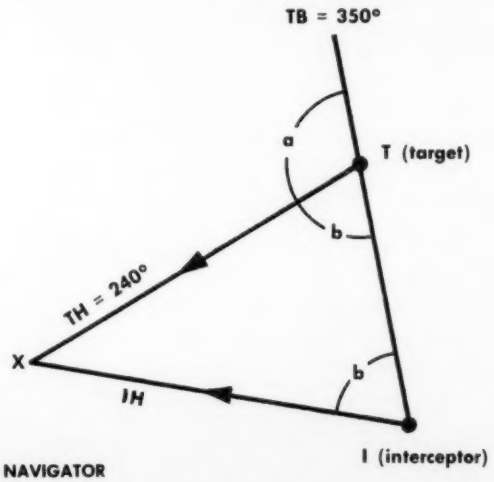
If we didn't know our *precise* location, the control point method of rendezvous was meaningless and many precious minutes of refueling time were lost. As a result, we usually tried to intercept each other as soon as possible after radar acquisition. The procedure was usually about as successful as the "eyeballing" ability of the navs concerned. There are some airspeed-adjust methods which assure that you do eventually get together, but the fastest possible way to get together in the air is to be able to fly a precise intercept heading.

The graphic solution in Volume III of AFM 51-40 takes too much time and requires an already burdened navigator to draw all the vectors on a chart. It is also a general solution, and covers all cases. Therefore, I was not satisfied and tried to devise a simplified method.

My solution deals with the intercept problem in those cases in which the true airspeeds of both aircraft are equal, or nearly equal. If the airspeeds are, in fact, equal, the determination of the intercept heading is simplified because one of the variables has been removed from the problem. In fact, it becomes simple enough that an accurate mathematical solution, rather than a graphic one, is not only possible, but practical.

Since the B-52 and KC-135 both fly at about 450 KTAS, I could easily match true airspeeds and eliminate a variable. Also, since I am dealing with two aircraft (not, for example, an airplane and a ship), I could base the solution on airplot (TH and TAS) rather than groundplot (TC and GS) and eliminate the wind factor from the problem.

The only factors remaining, then, are the true bearing (TB) of the target from the interceptor and the true heading (TH) of the target. The geographical location of either aircraft is not a factor, nor is their separation distance.



The interceptor acquires the target at a bearing of 350 degrees. The target is heading 240 degrees. In the perfect intercept, the distance each has to fly to the intercept point (X) must be equal if their respective airspeeds are equal, in order for them to arrive at the same time. The bearing (350) is a line of constant bearing and will not change throughout the intercept. The only factor I need to determine, then, is the intercept heading from I to X.

Since distances TX and IX are equal, we have an isosceles triangle in which the two interior angles, b, at the base are equal. The exterior angle, a, is 350-240=110 degrees.

a=TB-TH
b=180-a
b=180-(TB-TH),

and the heading that the interceptor must turn to is:

IH=350-b
=TB-b
=TB-[180-(TB-TH)]
=2TB-180-TH

The answer is mathematically certain, and it works every time. Remember, the wind has no effect on the success of the intercept, as long as the same general wind is affecting both aircraft.

Since there are only two entering arguments, a table can be made, based on the above formula.

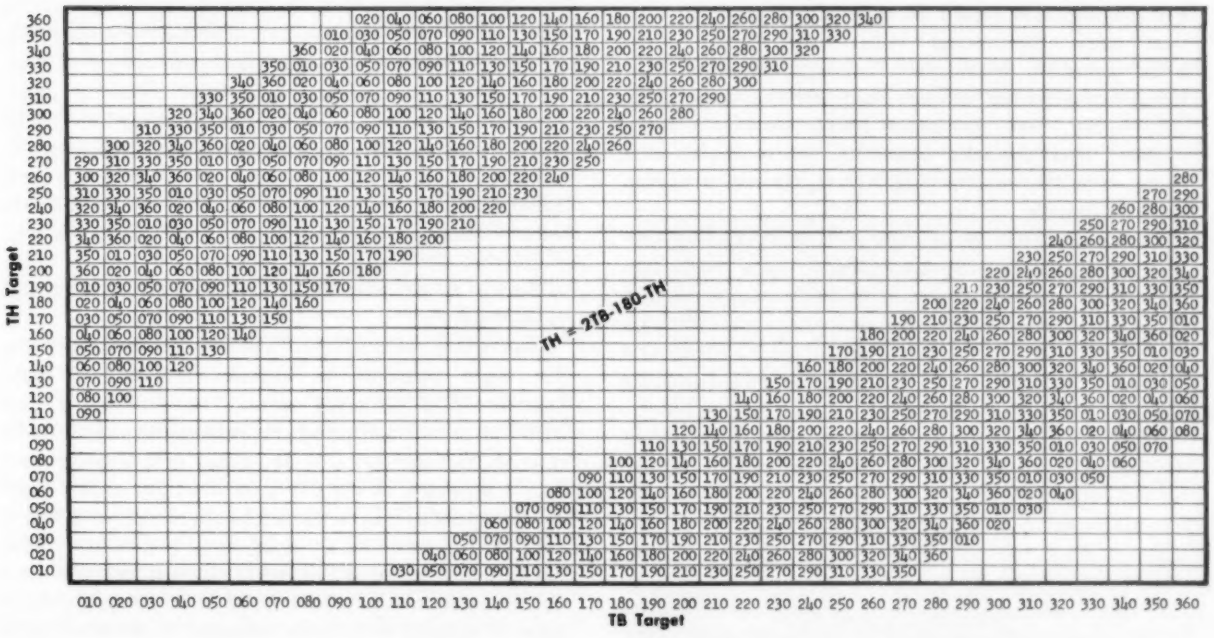
Now the intercept heading can be obtained at a glance, even if the target changes heading for weather. The blank area of the chart represents all those cases where the interceptor bears 90 degrees or more from the target's heading, in which case no intercept is possible unless something is changed. Either the target must turn more towards the interceptor, or airspeeds will have to be adjusted until the interceptor is once again within the magic 90 degrees of the target's heading.

In our example, entering the table with TB (of the target) of 350 degrees and TH (of the target) of 240 degrees, extract 280 degrees for the intercept heading. The same result can be computed from the formula. Thus:

IH=2TB-180-TH
=2(350)-180-240
=280 degrees.

An easy solution to a previously difficult problem!

INTERCEPT HEADING CHART



the OLD CROW GETS A NEW SEWT

The Electronic Warfare Old Crow will soon be "wearing" a new SEWT. The SEWT (pronounced "suit") is the AN/ALQ-T5 Simulator for Electronic Warfare Training. This new and valuable educational tool is to be used in the training of Electronic Warfare Officers in a unique non-flying syllabus. The value of simulation training has already been proven in many fields. In the dynamic field of Electronic Warfare (EW), the $5.8 million SEWT will completely replace actual flight training in the basic EW training course at an annual savings of $1.2 million.

Development of the SEWT began in June 1967 when ATC submitted a Required Operational Capability (ROC) to Headquarters, USAF. In May 1970, the Aeronautical Systems Division of the Air Force Systems Command awarded the SEWT contract to the AAI Corporation located near Baltimore, Maryland.

In developing the SEWT, the AAI Corporation often pushed the state of the art in both hardware and software design. Three years later, in-plant tests were completed and delivery was made to the 453d Flying Training Squadron (formerly the 3537th Electronic Warfare Training Squadron), Mather Air Force Base, California, in August 1973. In-place Air Force acceptance tests were completed in November 1973 and the first class is expected to enter training in January 1974. Additionally, the non-flying concept for training of EW officers will be implemented on this date.

The decision to implement a non-flying program for EW training was based on several assumptions: first, that basic airmanship skills were acquired in Undergraduate Navigator Training; secondly, that flying training had not kept pace with the state of the art; thirdly, that simulators could provide a more realistic and dynamic electronic environment; and lastly, that the results of a non-flying test program were favorable.

Two test classes were used in a study of the non-flying EW training program concept. These test classes received the same academics as their counterparts in the regular flying training program, but received twice the normal trainer missions in the AN/ALQ-T3 RB-47H Electronic Reconnaissance and the AN/ALQ-T4 B-52H ECM simulators.

The test program was divided into three distinct evaluation phases. Phase I contained all the background data on each student prior to his entry into Electronic Warfare training as well as documented data on his performance in the test program at Mather AFB. Phase II was an evaluation and comparison by CCTS personnel of the non-flying classes to the normal flying classes. Phase III was an evaluation and comparison of the two programs by the using commands. Data in Phases II and III included students' academic progress, number and grades from training flights required to become proficient, and their grades on the students' initial qualification flight check.

The results of Phases II and III were virtually the same. Non-flying graduates compared favorably with flying graduates.

ATC personnel briefed the results of the non-flying test program to the Air Staff in July 1972. Air Staff approved the non-flying training concept and recommended its implementation concurrent with delivery and acceptance of the SEWT.

The SEWT has been designed to reduce the number of inherent limitations or deficiencies of the T3 and T4 simulators as identified in ATC ROC 5-67. Designed for a specific task, these simulators are limited in their equipment configuration and must follow a single aircraft flightpath in a limited geographical area through a limited signal density environment. In addition, interphone crew coordination and communication facilities were found to be inadequate when related to operational standards. These simulators also require a 1:1 instructor to student ratio, a factor to be considered in the light of reduced resources.

The arrival of the SEWT will provide the capability for eight students to independently "fly" eight separate and different missions simultaneously. The SEWT is not configured to represent any specific aircraft, but contains a wide variety of EW equipment found on many of the EW aircraft. Each of the eight student stations is an enclosed booth complete with EW receivers, transmitters, analysis equipment, radar homing and warning receivers, navigation panel and communication equipment needed to complete each type of mission. With these features, students will now be able to train for four different types of EW missions:

W
EW
WT

Captain Stephen A. LEISHMAN
453d Flying Training Squadron
Mather AFB, California

electronic support measures (reconnaissance), electronic countermeasures, tactical EW support, and Wild Weasel missions. This capability far exceeds that of the simulators currently used in the training program.

In addition, the T5 has the capability for each student station to be tied into the same interphone and/or communications net with any or all of the other stations. This feature provides the opportunity for students to develop crew coordination as would be used in a multi-place aircraft or to develop a sense of coordination as a flight or cell of aircraft fulfill their roles in completing a mission.

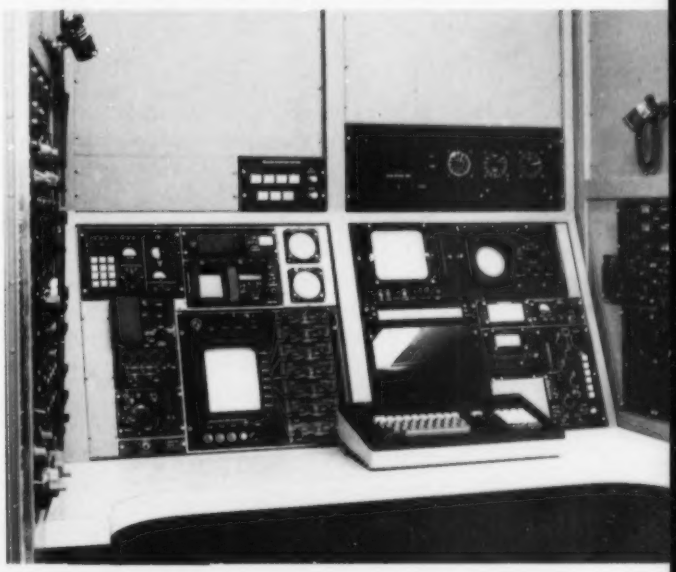
Also available in each student station is a Student Data Terminal (SDT) that includes a keyboard, a cathode-ray tube (CRT) for alphanumeric displays, and a mission status panel. The SDT will provide for computer-assisted instruction during equipment, procedure, and tactics laboratory sessions, for student-trainer interaction through evaluation of student responses and reactions, and for re-instruction of designed tasks if the evaluations are failed. The present simulators do not have the facilities to provide this type of re-instruction on an individual basis. With the T5, an individual student mission may be reset for re-instruction, and additional training may be given without affecting the other students.

The SEWT contains two evaluation systems, automatic and scripted. The automatic evaluation system was designed into the simulator to be used primarily during electronic reconnaissance labs or missions. When an error is detected, the system will automatically display an error message to the student on the SDT CRT or mission status panel. The second type of evaluation system is one that is scripted by a programmer into a lab or mission. There are four kinds of scripted evaluations used to check student actions required to be accomplished in a designed sequence, to make instantaneous evaluations of these actions required to have been completed in a short period of time, to evaluate any student actions that may be prohibited, and to evaluate a collection of designed actions which were to occur over an extended period of time.

The use of these evaluation systems will greatly reduce the instructor to student ratio and, therefore, will reduce the number of instructors required for the training program. The new SEWT syllabus requires a 1:4 instructor to student ratio, plus a console operator to conduct training labs and missions. Trainer check missions will require only a 1:8 instructor to student ratio. As an added feature, reduced ratios and use of the T5 evaluation systems will increase the objectivity in student grading to produce a standardized student evaluation score.

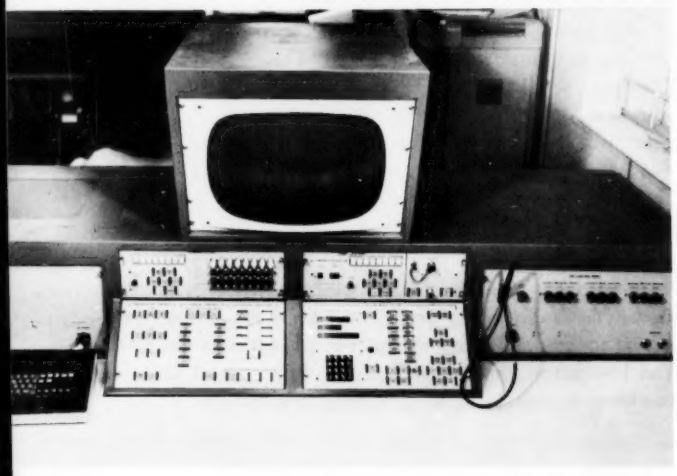
At the conclusion of each lab or mission, a post-mission printout is automatically available for students and instructors to review. The post-mission printout will be in two forms, short and long. Each form will have a computed overall grade in addition to a list of the grades from each of the scoring categories as defined in lab or mission development. The long form is identical to the short form except that it includes detailed error information. From these post-mission printouts, instructors will be able to critique a student's performance, identify weak areas, and recommend corrective action if necessary.

T5 Student Station. The right panel contains communications equipment. The right side of the front panel contains reconnaissance equipment and the SDT. The left panel and left side of the front panel contain countermeasures and Wild Weasel equipment.



Monitor functions for the eight student stations are handled at the Instructor/Console Operator position. The console contains a CRT whose alphanumeric graphic displays allow the console operator to monitor the progress and problems of each mission or student. Once a console operator identifies a student with a problem, he may offer instruction from the console while he monitors the student's action on the CRT, or he may send a ratio instructor to the student's booth. This feature is a vast improvement over the present training program where an instructor/console operator can monitor only one student and has little control of the mission progress or the problems of other students. Other controls at the console provide the operator with the ability to monitor and control mission progress, to monitor any or all interphone and communications messages, and to introduce real-time changes into a training lab or mission.

SEWT Instructor/Console Station. The large CRT enables the instructor to monitor any student's action in detail.



The heart of this one-of-a-kind simulator is a signal generation system, controlled by a digital computer. Under the control of a real-time program capable of controlling, monitoring, and updating the eight student stations and the instructor's console once every second, this signal generation system can simulate all known friendly and hostile radio frequency signals. Up to 126 emitter signals may be simulated on-the-air at one time to produce a realistic EW environment. This capability is more than twice the signal generating capacity of the T3 and T4 simulators. Digital operation was selected over analog operation because of its greater capacity to handle more complex problems with greater accuracy at faster speeds in a smaller physical area. Additionally, SEWT signals will automatically come on and go down as the student's aircraft flies into and out of range of each emitter. Signal power levels will also vary relative to the range of the aircraft from the emitter site.

SEWT missions may be programmed to operate in any part of the world. Each mission can operate in a large gaming area, 2000nm x 2000nm x 100,000 feet. Within this area, the students' aircraft may fly at any speed up to 2000K. Three different types of present day aircraft flight characteristics have been programmed to be used for the students' missions. Multiple aircraft simulation for each mission is also available. Up to five other aircraft may be simulated at one time to fly as either friendly or hostile aircraft. These aircraft may have the same or five different aircraft flight characteristics. The availability of these different flight characteristics greatly enhances the flexibility and realistic presentation of a training program.

An additional feature of the SEWT is its short turnaround time between labs or missions. The completed changeover can be accomplished by the console operator and a few maintenance personnel in less than one hour. This desirable feature will lead to more effective use of the simulator and eliminate the present scheduling problems which were caused by the amount of time required for maintenance personnel to complete signal generation and mission changeover in the T3 or T4 simulators.

Two years ago, nine squadron instructors of varied educational and experience backgrounds were selected to form a SEWT element within the 453d Flying Training Squadron. The element was tasked to assist in the writing of a SEWT syllabus whose objectives would bring out the full advantages of the new simulator in a non-flying program. Currently, the SEWT has just completed the Air Force acceptance tests and these nine instructors are developing and debugging the 33 labs and missions programmed for the new syllabus. When the SEWT program is implemented, these nine officers will become the initial cadre of instructor/console operators. Shortly thereafter, these people will be rotating to new assignments.

If you are an Electronic Warfare Officer, particularly with a computer background, and desire an assignment in ATC at Mather AFB, now is the time to make your desires known and to change your Form 90. *The Old Crow has a new SEWT.* And the new SEWT has a tremendous growth potential and the flexibility in both hardware and software to serve for many years in the dynamic field of Electronic Warfare.

AWADS— What's AWADS?

Robert F. ERICKSON
Marketing Communications
Texas Instruments Incorporated

The development of a new generation operational radar seldom rates a headline in a newspaper; yet, to the men who fly the aircraft, a new radar can mean a great deal. Improved resolution, increased reliability and improved mission efficiency are but a few of the improvements expected from a new system.

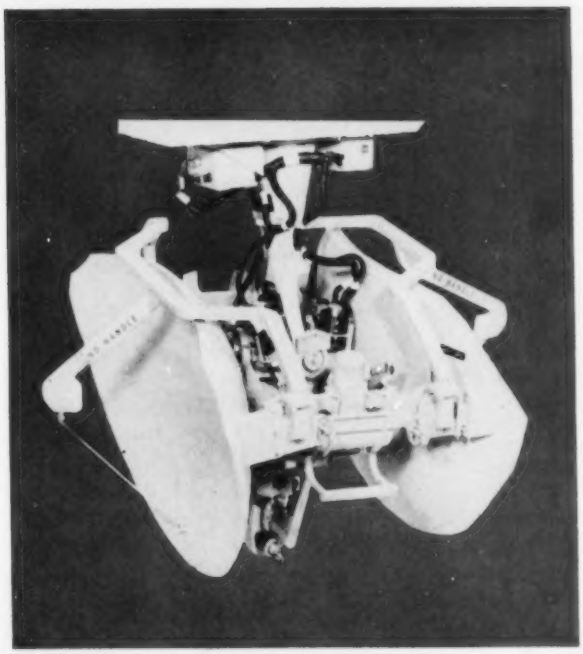
The AN/APQ-122(V) series of navigational radars is just such a system. Designed by Texas Instruments Incorporated, Dallas, Texas, as the primary sensor in the Adverse Weather Aerial Delivery System (AWADS), the AN/APQ-122(V) introduces state-of-the-art technology to the navigational radar for large transport type aircraft.

In its AWADS configuration, the dual-frequency radar (X and Ka-Band) has been designated the AN/APQ-122(V)1. It is designed to work with other navigational sensors in the C-130 aircraft. The radar features very high resolution and extended range coverage to supply accurate data to the system's digital computer for determining the Computed Air Release Point (CARP). The program specifications called for airdrop accuracy of 100 meters. Operating independently of any ground-based aids, the system has met and exceeded all specifications.

AWADS is an integrated system; the radar and other sensors are linked together through a digital computer which contains all pertinent pre-mission data. The navigator can update the information enroute as conditions change. Radar video is provided on both pilot and navigator displays. In addition, the computer continually presents steering commands to the pilot through the Horizontal Situation Indicator and the Attitude Direction Indicator. The autopilot also receives an input from the computer such that the navigator can "fly" the aircraft to the desired drop zone, through updates and course changes.

The AN/APQ-122(V)1 provides four basic capabilities which include long-range ground mapping, beacon interrogation, weather detection, and precision fixing. These modes of operation provide the Air Force with a true solid-state radar system that provides a day/night, all-weather navigation capability.

The dual-dish radar antenna is gyro-stabilized in pitch and roll axes and doppler-stabilized in the yaw axis.



The AWADS radar also includes some unique features designed specifically to provide for growth. Using modern design techniques, the radar was constructed in a modular fashion so that a given performance capability could be added or deleted as required for a particular aircraft or mission. This versatility makes the radar suitable for many missions being performed by the Air Force today. In addition, the radar system was designed for installation in many aircraft other than the C-130.

The modular design of the 122(V) radar series has allowed this versatile system to be expanded to include almost every mission for large transport aircraft used by the Air Force. For instance, one configuration of the 122(V) radar is a direct replacement radar for the successful, but aged, AN/APN-59 navigational radar. Also, the addition of modern equipment, such as the AN/APQ-122, will greatly improve an existing aircraft's contribution to current Air Force goals.

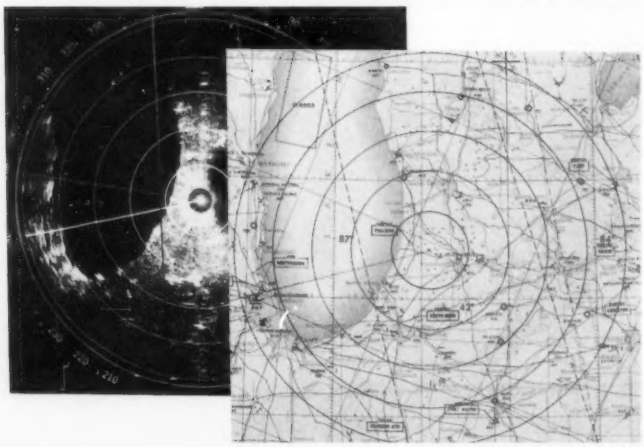
The natural evolution of the 122(V) series of radars to date has resulted in three derivative radars. A single-frequency system, denoted (V)5, operating at the X-Band frequency only, has been developed for other transport aircraft. It serves as a replacement for the AN/APN-59 radar. The APQ-122(V)7, of major interest to the navigator, has 14 displays and is used as a training radar system. The addition of a terrain-following / terrain-avoidance capability creates a system called the AN/APQ-122(V)8.

As stated, the AN/APQ-122(V)7 system is of primary interest to the navigator. The (V)7 radar is currently designated as the primary training aid in the new T-43 navigation training aircraft.

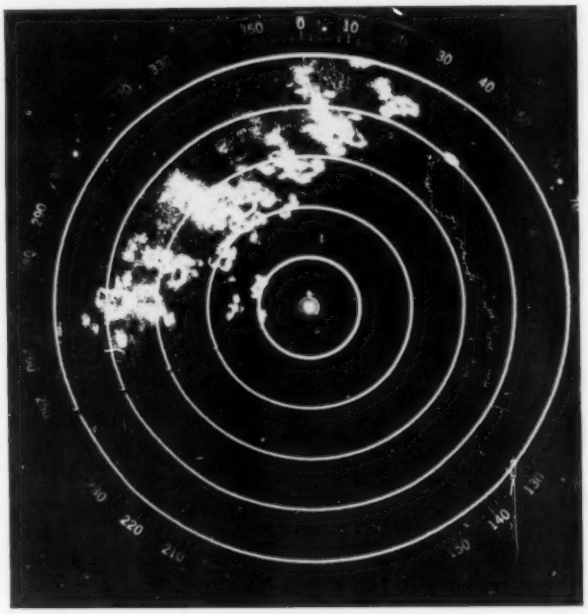
The (V)7, also an X-Band radar, is configured to provide video to 14 display stations. These include a master station, two proficiency stations, and 11 student stations. The master station controls the basic radar functions such as operating modes, antenna position, and scan rates. With certain restrictions, the other 13 indicator stations have individual control of their respective displays. Each station, except the two proficiency stations, has a cursor control allowing the operator to update displayed azimuth and range cursor information received from a digital computer external to the radar set.

The AN/APQ-122(V)7 features three basic modes of operation, including mapping, weather detection and beacon interrogation. These modes of operation are identical to those of the operational AN/APQ-122(V)1, (V)5, and (V)8 radar systems.

In mapping mode, the radar range is in excess of 150nm.



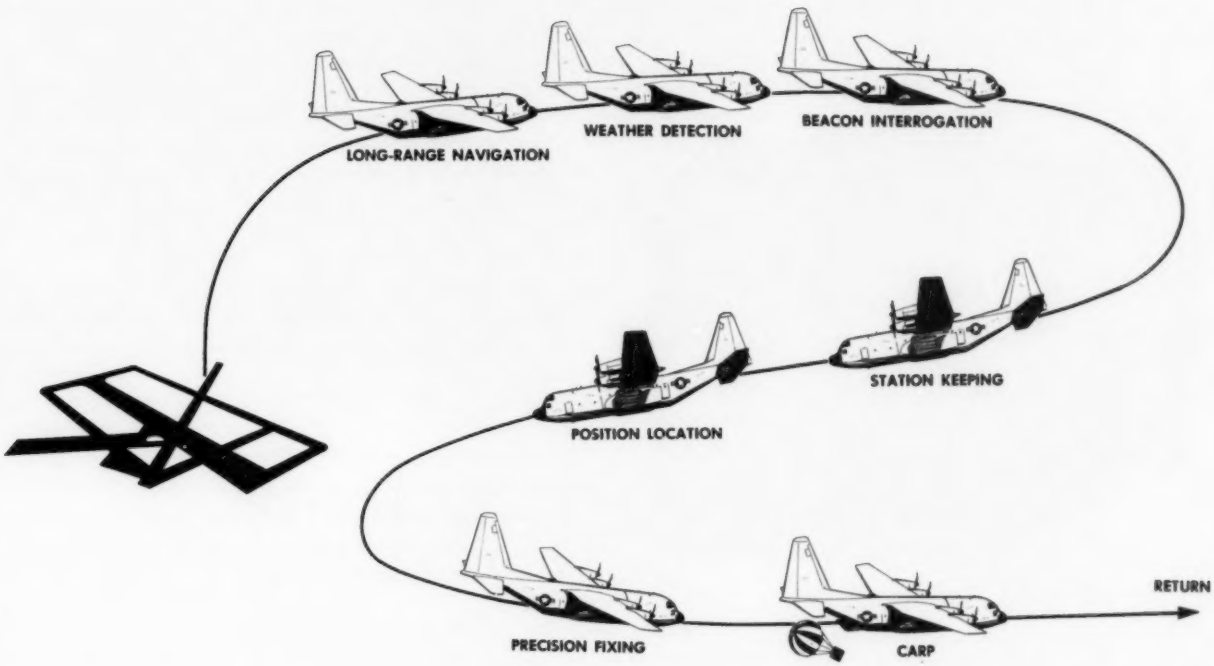
Typical weather detection mode presentation.



In the mapping mode, the radar can detect and display shorelines and mountains at ranges in excess of 150nm. The radar employs antenna beam shaping and receiver gain programming to achieve a uniform ground map display from 3 degrees to 50 degrees below the horizontal. This ground map capability extends from 200 to 50,000 feet above the terrain.

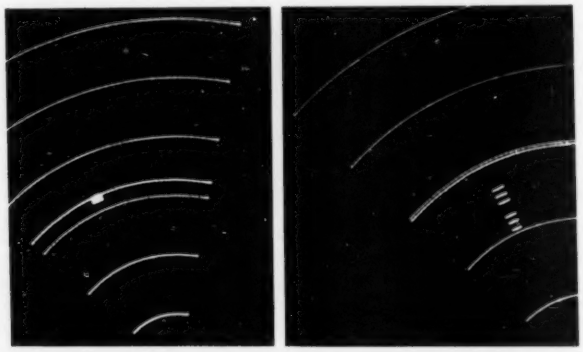
The weather detection mode is used to detect weather cells and evaluate the intensity of these cells through iso-echo contouring. The radar uses the pencil beam antenna in this mode and is capable of displaying a 3nm diameter, 25 millimeter-per-hour weather cell at a range of 150nm with intervening light weather.

With the (V)7, it is possible to perform beacon interrogation at line of sight distances of 240nm. The beacon reply may be expanded for identification by using the range-delayed variable length sweep.



The probable radar circular error is no more than 2300 feet at a slant range of 50nm. This error is minimized through the use of a dual-dish antenna which is gyro-stabilized in pitch and roll axes and doppler-stabilized in the yaw axis. This antenna will scan 360 degrees at either 12 or 45 revolutions per minute, sector about a manual or azimuth cursor position with variable sector width, tilt up or down, and scan in a searchlight fashion at the master station operator's discretion. All of the circuitry required to drive and monitor the antenna is contained in the Electronic Control Amplifier.

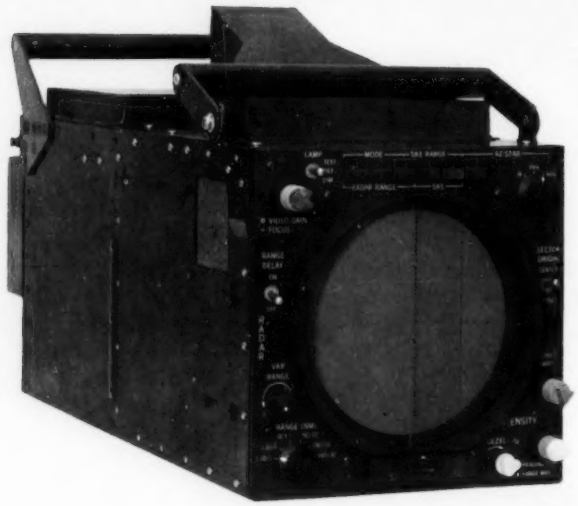
Beacon interrogation is possible at ranges in excess of 200 miles.



A unique line replaceable unit (LRU) in the (V)7 system is the Indicator Coupler. This LRU, which receives signals from the antenna, electronic control amplifier and receiver-transmitter, distributes power for the entire radar system and drives all 14 indicator positions. The video is coupled to the indicators through the Indicator Coupler via isolation amplifiers from the X-band receiver-transmitter. The receiver-transmitter has a line-type modulator and log receiver with a minimum discernable signal specification of at least -106 dBm in the smallest bandwidth. In addition to a programmable receiver gain (STC), selectable fast-time constant and frequency agility to enhance radar video, the receiver-transmitter unit has nine selectable operating frequencies.

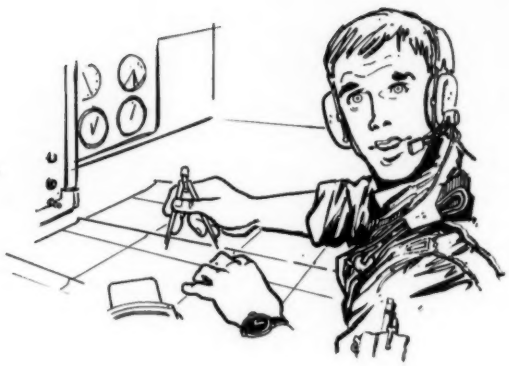
Each of the 14 Navigator Indicators present radar video and selected computer-driven electronic cursors on a seven inch, high resolution, cathode ray tube. There are five selectable ranges (8nm, 30nm, 50nm, 100nm, and 240nm) with range marks at convenient ranges. The 30nm range is variable via a front-panel potentiometer from 3 to 30nm to facilitate target identification. This variable sweep can also be range-delayed in the 50, 100, and 240nm ranges to bracket the slant range cursor input received from the computer. Front panel potentiometers also control the intensity of the video, sweep, slant range and azimuth cursors, heading marks, and range marks.

AN/APQ-122(V)7 Navigator Indicator.



In addition to the standard PPI display, the indicator will present an offset sector PPI with range sweep originating at the edge of the display and extending across the usable face of the tube. The vertex of this offset display is maintained at 180 degrees from the center of the sector relative to the selected bearing (North, Track, or Heading) chosen at the master station. Each station has the capability of adding magnetic variation to the North-stabilized display.

The AN/APQ-122(V)7 was designed specifically to prepare navigation students for the complex radar systems currently in the Air Force inventory and for those systems which will be used in the coming years. Features such as computer coupling are incorporated to insure that each student is fully prepared for operational equipment and missions. The (V)7 provides the Air Force with the latest tool in training in an operational environment, and because the radar is designed using up-to-date modular techniques, it is easily adaptable to the requirements of the future.



Momentary Disorientation

Major John R. BARNEY
8th Air Force
APO San Francisco 96334

"Pilot, this is Nav."

SILENCE

"PILOT, THIS IS NAV!"

"Yeah, Nav."

"Pilot, our ETA to 180 East is 1420Z."

"Rog, Nav. What time will it be Local when we land?"

SILENCE

"By the way, Nav, the Metro Flight Plan now shows 10 degrees difference from our heading and 15 minutes difference in ETA."

"GULP!!!"

Well, there you are. It's a beautiful day, and you're cruising across the Pacific in your giant Boeing KC-135 Stratotanker. The only sounds are the roar of the engines and the gentle crunch of peanuts as the copilot eats his third flight lunch. Everything is working beautifully except your boom operator. Your DR and celestial appear to be good. Your equipment looks OK. How come the Metro Flight Plan is suddenly so different? The doppler hasn't shown any change. Maybe you are lost!!!

Why not get an HF/DF line of bearing?

Do what?

Why not get an HF/DF fix? Well, why not?

I'll tell you why not. I never did, because I didn't know you could. All the pilots I talk to say *they* always knew about HF fixing procedures. So how come they never told me? All I can assume is that every AC I had must have had supreme confidence in my ability. Maybe he liked my lumpy charts caused by the sweat dropping gently from my

forehead. I do recall a time or two when a line of bearing or fix from something besides Celestial would have been reassuring, particularly prior to ADIZ penetration.

This procedure can really help the SAC aircrews, since most of their aircraft are not Loran-equipped. For whoever might need them, the procedures are outlined in the following paragraphs.

All USAF HF aeronautical stations except Loring, Croughton and Incirlik have the capability of providing you HF/DF information upon request whenever you are in radio contact. The items which should be included in your request are call sign, reason for your request, and the frequency on which you are transmitting. Example: "Andersen Airways, this is PELT 71. Request line of bearing and/or fix from your station. (Reason) I am (unsure of position, nav aids inoperative, et cetera). PELT 71 transmitting on (frequency). I will stand by."

The station will then request a long or short count. If you have requested a line of bearing, you should receive a reply from the HF station called in approximately five minutes. Example: "PELT 71, your line of bearing from Andersen is 273 degrees." If you have requested a fix, you should receive a reply in 10 to 15 minutes, similar to the following one. "PELT 71, your position is 14 degrees 10 minutes, 135 degrees 20 minutes at 1435 Zulu."

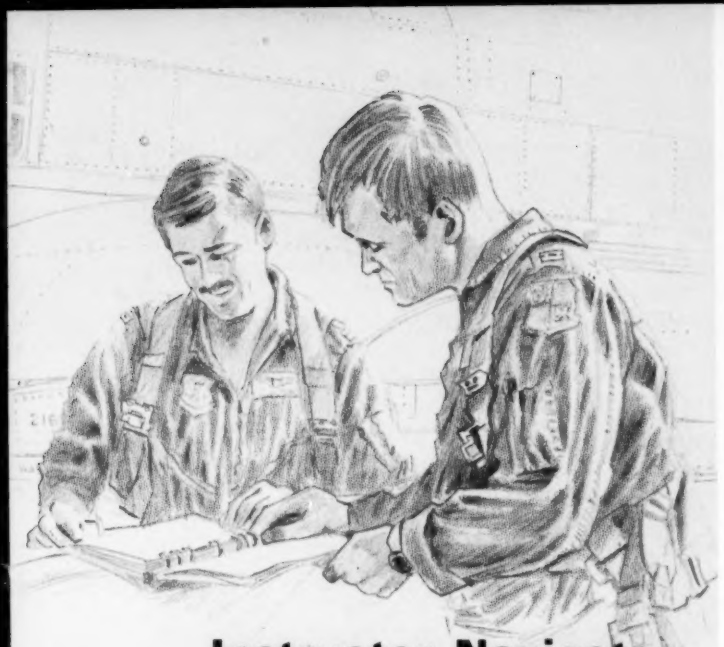
It's easy to see how an HF/DF station can give you a line of bearing. They tune in your frequency and their DF compass needle homes on your transmission. It's just the old ADF bird dog trick. But how can they give you a fix? Let's say, for example, your position is somewhere over the Philippine Sea and you are in contact with Andersen Airways. Here's what happens when you request a fix, using the format discussed. Andersen Airways will call their supporting DF facility and they, in turn, will activate two other appropriate DF units. In this case, the other stations would probably be located in the Philippines and Japan. Andersen will then request that you give a long or short count. (If you're too nervous to count to ten and back, count to five and back, twice.) The supporting stations would then obtain a line of bearing from your aircraft and pass it to the Andersen DF unit. The DF operator then plots his line of bearing and that of the other two, resulting in a three station fix. Remember, only USAF Global HF Aeronautical Stations, as listed in the Enroute Supplement, have DF support capability. If you request a bearing or fix from stations other than those listed, you'll both be lost.

The station will provide you with the accuracy of the line of bearing or fix, upon request. The fix will be classified as A, B, or C. If in reference to a line of bearing, you can expect accuracy to within plus or minus 2, 5, and 10 degrees, respectively. If in reference to a fix, you can expect accuracy to within 5, 20, and 50nm, respectively. If the DF facility is not located at the airways station, you will be advised in the reply. For example, if you call Fuchu Airways, the reply may be: "PELT 71, your bearing from Misawa is 180 degrees."

All ocean station vessels have HF/DF capability to provide a line of bearing. It may be necessary to request the HF ground station, with whom you are in contact, to ask the ocean station to come up on their HF frequency, which is found in the Enroute Supplement. The procedures described above are in accordance with Allied Communications Publication 130-c July 1971, A.C.P. 121 U.S. Supp.-2 Para 621, March 1973 and AFCS SU Form 102, Sep 1972. Since this procedure ties up a frequency for an extended period of time, it should not be used as a fixing procedure under normal conditions. Don't forget to have GNC chart coverage for your area. It sure would be embarrassing to obtain a line of bearing and then not be able to plot it. With good celestial procedures, DR, et cetera, you will probably never need to use HF as a nav aid, but someday it might be all you have.

"air crews are friendly to Navigators... overwater...

Guest Cartoonist: **Capt Gregory J. SHEBEST**



Instructor Navigator: *More Than a Title?*

Major Robert ZUCKER
95th Strategic Wing
APO New York 09677

I think I'm a typical navigator. I progressed from a coarse, green KC-97 navigator, 1960 vintage, to a KC-135 Combat Crew Training School (CCTS) Instructor Navigator in the Standardization Division before my current staff duties. I am now at the point where I'm fairly confident that I can navigate from point A to point B with relative ease no matter what the wind—and that's the whole point of navigation, isn't it?

During the past 13 years, I've come into contact with a multitude of instructor navigators, or at least men who were listed as instructor navigators on the records. A few were excellent, most were good, and some were downright inferior. Unfortunately, the inferior ones stand out most in my mind. Rather than improving my ability as a navigator, they fostered uncertainty, a lack of self-confidence, and pure frustration. The main thing I remember about the excellent ones was that they had the patience and empathy to let me learn.

I once had an instructor who was an organization man. In other words, my map had to be perfectly centered on the middle of the nav table, my checklist on the left side, my dividers, plotters, pencils, et cetera, on the right side, and my flight lunch on the floor by my right foot. By the time I located everything, instead of being at point B, I was at point C, which unhappily was 50 miles off course. Everytime I tried to call the pilot on interphone, I stepped on my flight lunch. Everytime I moved my checklist to where I could view it comfortably, he'd move it back to where it "belonged." His way was the only way; it sure was a nerve-wracking, unproductive experience. Learning is basically a change in behavior. The only change in behavior he accomplished was my growing friendship with the scheduling officer so I wouldn't have to fly with that particular instructor anymore.

I remember another instructor. He was a demonstrator. For eight long hours, I stood behind him and watched a "real pro" navigate, make a rendezvous, and do all the other little things navigators do. After each activity, he would turn around to me and say in the self-confident voice of a Little League manager, "See, that's the way it's done!!!!" Each time he'd say this, I'd nod my head vigorously, and, smiling, he would stick his head back into the radarscope. My main learning outcome for this mission was the invaluable ability to sleep on my feet.

Let me give one more example. I had an instructor who was the helpful interrupter. If I was in the middle of a precomp, he would tell me not to forget to reset my altimeter during the penetration. If I was making an airborne radar approach he would tell me a short cut on figuring out a target timing wind. If I altered the aircraft five degrees to the left, and it was supposed to be two degrees to the right, he would immediately let me know, even though we were flying a navigation training mission and Center had cleared us to go any place in the world. What was the learning outcome? CONFUSION.

What is the purpose of all this? I'm sure you, the reader, have had similar experiences, and like me, have survived to achieve the ability of getting from point A to point B. It certainly would have been much better if, instead of leaving behind a trail of people whose main claim to fame is simply the title of instructor navigator, our careers had been a series of one excellent instructor after another.

In the Air Force's CCTS programs, an attempt is made to get the best instructors available and turn them into even better ones. CCTS's are the heartline to the operational squadrons in the field. They get upgrading navigators directly from undergraduate navigator training, Southeast Asia, and other commands. They are taught the singularities of the particular command's navigation procedures and the equipment on their aircraft. An inferior CCTS instructor can cost an operational squadron instructor many hours retraining a newly graduated navigator.

CCTS's constantly strive to improve their programs and their instructors. They recruit only the best navigators, but it is obvious from my opening statements that this is not enough. It is simply the Peter Principle in action. Because a man is a good navigator—the best in the world,in fact—it doesn't mean he will be an outstanding instructor. As an instructor, he may have finally reached his level of incompetence.

Happily enough, though part of being a good teacher is inborn, much of it can be taught. But first, the man must have an intense desire to instruct, rather than just the yen for the title to enhance his promotion opportunities. His personal characteristics must include sincerity, patience and enthusiasm. He must have empathy for the student. In other words, he cannot forget about the time when he was just starting out. If he can infiltrate the thinking process of the student and understand the problems he faces, he will be money ahead. The approaches to the hard worker/slow learner, hard worker/fast learner, or unmotivated loafer with good potential must all be different.

Remember, substandard navigation can result from inferior instructor. Any teacher who blames his student for failure should *first* look into his own teaching techniques where he could find the real guilty party.

Navwords

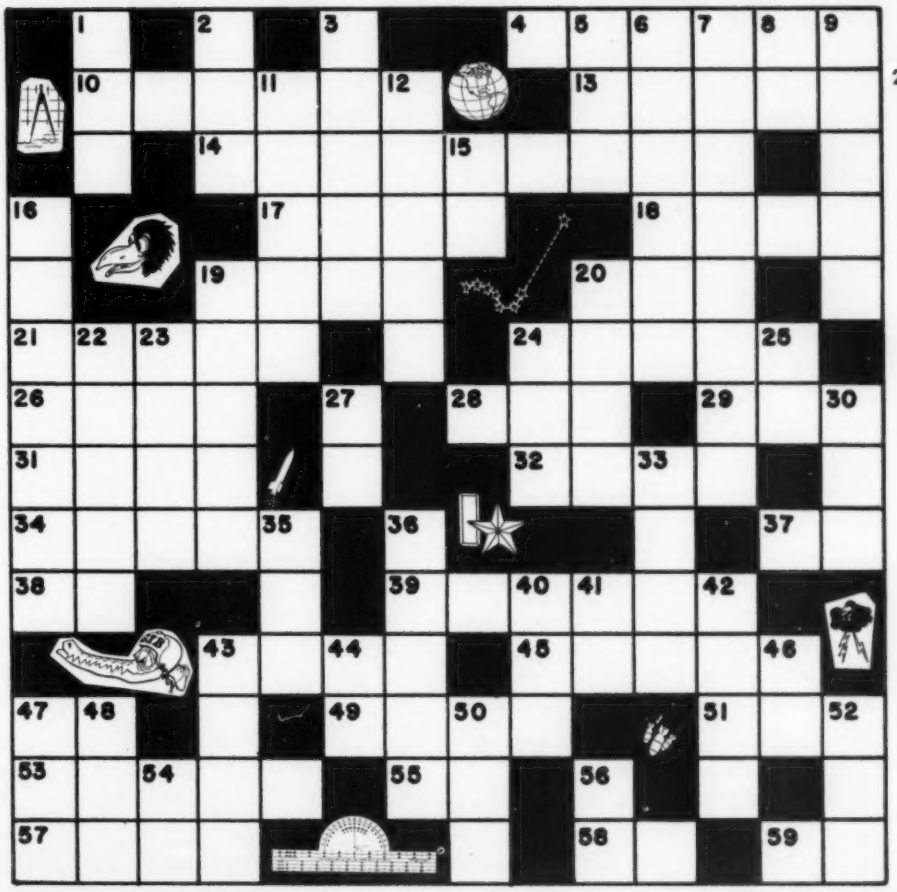
ACROSS

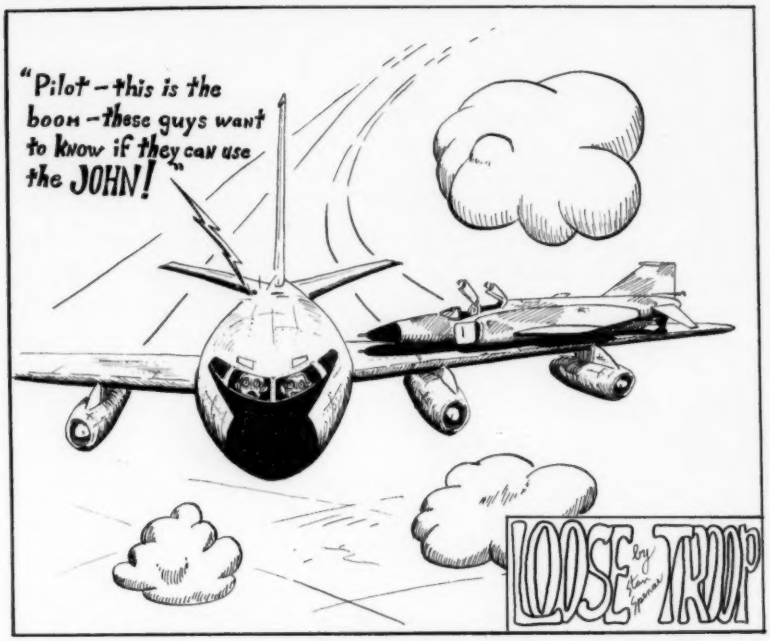
4 Bridge term
10 Method of navigation popular during the Korean Thing
13 Don't get your neck in this
14 The crew depends on this
17 Prefix: Ten
18 An important item to consider on long flights
19 Jet _____
20 Thailand is there
21 Type of navigation
24 What we all think about
26 Something you do inflight
28 Zero
29 Navs usually dislike flying one
31 What you want to do for a long time
32 C.O.
34 All
37 You should want to be one
38 About
39 Red ones are usually bad
43 Cargo carrying navs know this one
45 William Tell and SAC Bomb Comp
47 Like
49 Tan Son _____
51 Tanker navs belong to one
53 You can gamble (or gambol) at this lake
55 What you log when not performing at a duty station established for your specialty.
57 It takes two to make one
58 Greek letter
59 Conjunction

DOWN

1 Uncle Sam's country
2 It's heavy
3 It may be hard to get drift from these
5 Where we all started
6 Tanker crews have one
7 Corona _____
8 A letter
9 What errors can do
11 A neat aid to navigation
12 All navs find one
15 Your hack watch is
16 Its explanation is usually compared to sound theory
19 Some folks use wine instead
20 Where a missile is kept
22 Every martini has one
23 What we all need
24 Two of these were aces
25 Ave.
27 Our branch
30 These make machines
33 Richmond Bomb Plot is one
35 Sure!
36 The first letter
40 Zulu
41 Pronoun
42 Sabik is one
43 Many aircrews have one
44 See 43 Down
46 _____ 71
47 5 Down's Command
48 Thanks to this operation, many of us are alive and well
50 One, in Madrid
52 This one looks sideways
54 Not she
56 Where the wild blue is

NAVWORDS Answers on page 27.





Guest Cartoonist:
1/Lt Stanley R. SPENCER

Optimum Velocitation

General, what are your plans for the next war?

There won't be any next war.

Why not?

When all the other nations hear about our plans, they won't dare to start a war.

What are the plans, General?

First of all, we will restrict our entire offensive to the air. By fabricating an overwhelming offense, we can ignore defense. This can be achieved by dread-naughts of the air. We refer to them as airnaughts.

What will the airnaught be like?

It will operate on the closed shuttle principle.

What is the closed shuttle principle, General?

This is a procedure whereby an aircraft can bomb a target and keep on going, to return to its starting point without turning around.

Do you mean they will fly completely around the earth?

That's it exactly.

General, how can we build planes that can go that far?

The details aren't worked out yet but the idea is comparatively simple. If one plane can go 5,000 miles, two planes can go 10,000 miles. Now, if you double the fuel load of those planes, you get 20,000 miles. Actually, we won't need as much fuel as that, because the planes will go faster.

How much faster?

Well, a plane that is standing on the ground is traveling about 1,000 mph because the earth rotates about 24,000 miles in 24 hours. We should be able to add another 1,000 mph to the plane's initial, or static speed, and thus get around the world in 12 hours. We can travel in a direction which will provide a tailwind all the way. That will give optimum velocitation.

Will the airnaught carry any payload?

Definitely. Every member of the flight crew will draw flight pay.

I mean bomb load, General. With such a load of fuel, how do you propose to carry any bombs?

We have written specifications for bombs which will be absolutely devastating and must not exceed 1 lb. in weight. We refer to those as bombmites. The control button console should not weigh more than 30 lbs. for full equipmentation.

Are you going to have any trouble getting enough fuel for your airfleet?

None at all. We are working on a fuel recovery system by which each plane reprocesses the exhaust products of the plane ahead, and thus manufactures most of its own fuel.

How does the first plane in line get its fuel?

There won't be any "first plane." There will be a continuous ring so that each one will have a plane ahead of it. This constitutes a sort of endless bomb belt.

General, this is remarkable. Does it mean that all your planes will have to stay in the air continuously?

Not necessarily, but that is a feature we are working toward. The thought is that if our planes won the last war by staying in the air only six hours a day, they can win the next one four times faster by staying in the air 24 hours a day. Or, in the same length of time the same job can be done by one-fourth the number of planes.

That means you would re-fuel in the air?

We would go much further than that. We expect to re-service the plane in all respects, and exchange flight crews while airborne. Thus we can dispense with bases. Of course the aircraft will land once every four years to allow the crews to re-enlist. But when we ultimate this program, you will find that all phases of warfare will be completely serialized.

How are we going to handle the enemy's defenses against your bomb belt?

He won't have any.

Why not, General?

As I explained, we propose to devote all our potential to the offense. Practically all other powers will do likewise since they pattern their forces on our organization. Thus an enemy is bound to get caught without any defense.

Are there any other developments I can mention in connection with your publicity?

Well, under our directivation the project engineers are working up an interesting list of devices. These include projectile traps and stratomines. The binocular electronic system also gives us some very valuable and expedient military implements. Among them are missile reversers, blind underway remote photograph (BURP), and electronic camouflage (Chameleonics). Retroradar will permit keeping the bombsight on the ground. Thus, the groundier will take over the bombardier's job, which will eventually be handled automatically. As you can see, we have just about eliminated the man from the problem. The next logical step is to eliminate the machine. We call this demechanization.

General, are there any obstacles to your plan?

We are worried about de-objectivation.

What is that?

Target shortage.

Thank you, General, for the interview.

Editor's Note: Reprinted with glee and tongue in cheek from the Spring 1954 issue of AIRCRAFT OBSERVER, known today as THE NAVIGATOR magazine.

	1 U		2 T	"	3 W			4 R	5 U	6 B	7 B	8 E	9 R
	10 S	H	O	11 R	A	12 N			13 N	O	O	S	E
	A		14 N	A	V	I	15 G	A	T	O	R		C
16 D				17 D	E	C	I			18 M	E	N	U
O			19 W	A	S	H			20 S	E	A		R
21 P	22 O	23 L	A	R		E		24 G	I	R	L	25 S	
26 P	L	O	T		27 A		28 N	I	L		29 I	T	30 M
31 L	I	V	E		F			32 B	O	33 S	S		E
34 E	V	E	R	35 Y		36 A				I		37 I	N
38 R	E			E		39 L	I	40 G	41 H	T	42 S		
			43 C	A	44 R	P		45 M	E	E	T	46 S	
47 A	48 S		R		49 N	H	50 U	T			51 A	R	52 S
53 T	A	54 H	O	E		55 A	N		56 U		R		L
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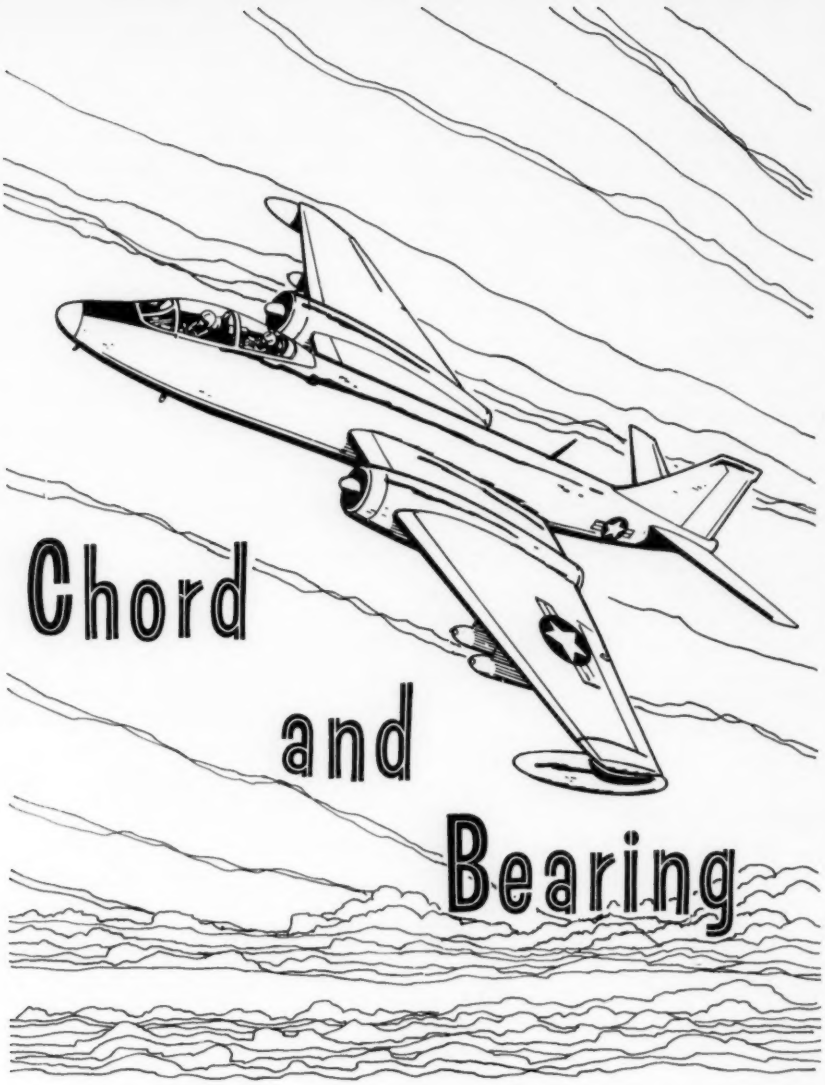
Guest Cartoonist:
Capt Gregory J. SHEBEST



Chord and Bearing

Major Kenneth A. KRAMER
93d Bomb Wing
Castle AFB, California

Have you ever paused to realize the various ways of plotting around a turn, and how many are being used today? They range from using dimes to using homemade circles in order to draw the arc of a turn. Once the arc is drawn, there are still more ways that are employed in figuring the rollout position. These techniques may include: plotting the distance of aircraft travel along the arc; plotting a tangent, equal to rollout heading, to the arc of the turn; plotting a bearing, equal to one-half of the amount of turn, from the start turn position to intercept the arc; plotting the rollout by eyeballing the comparison to planned track; and still others. Some of these techniques are employed with the assumption that it's close enough for government work. A very poor assumption, but one that seems valid due to the *expected* loss of accuracy during a turn. Hopefully, this expected loss of accuracy should no longer be a problem, as we will see later.

Let's discuss a few of the methods mentioned thus far. First, a few words about the dime method. The accuracy in using a dime for drawing an arc is completely dependent upon the pilot making an exact eight-minute turn (¾ degree/second), at an airspeed of 450K. If this expected eight-minute turn is deviated from, and more often than not it is, an error of up to five miles is induced into the rollout position, providing that the tangential or bearing method is employed in conjunction. If the turn was timed and the respective method of measuring distance of aircraft travel along the arc was used, then a total error of up to eight miles may be induced. These errors are based on a six-minute turn (approximately 24 degrees of bank angle) and an airspeed of 450K. As you can well imagine, this method lacks flexibility and accuracy (unless an exact eight-minute turn is enacted), but does retain the ease of plotting, provided one is financially prepared.

Secondly, a few words about procedure-turn plotters, templates with various size circles cut out to equal certain procedure turns. If properly used, the accuracy standards are acceptable. Nevertheless, in many cases, they are not properly used. One method of using the plotter is to initially time the turn, then to enter a radius-of-turn graph and match a circle with the computed diameter of turn, and then draw the applicable arc of turn. At this stage, the only difficulty and possible error would be the need for a radius-of-turn graph and the inability to select the proper circle to match the diameter of turn: possible error is up to two miles. If the rollout position is determined by measuring the distance of aircraft travel along the arc, up to four more miles of error may be present. If the rollout is determined by the tangential method, an additional mile or two may be induced. If the bearing method is used, the error will be negligible. If ideal conditions exist, these errors may compensate each other. Although, when accuracy is most needed, due to other problems encountered on the navigation leg, these ideal conditions are nowhere to be found. I am assuming, of course, that your luck is no better than mine.

Thirdly, many navigators still choose to groundplot (DR positioning) around turns. The employment of this method has the same accuracy standards as those mentioned earlier, provided the wind values are properly applied to the rollout position. Many times, the wind is just eyeballed and, excuse the pun, the method of "navi-guessing" is then employed, just as it was in some of the earlier techniques that we have discussed.

In retrospect, drawing the proper arc to aid you to find the aircraft rollout position does have its limitations. One, which we have not discussed, is being able to adequately determine where to start the arc. In other words, beginning the arc at a point where it is tangent to the inbound heading. In respect to those that we have discussed, you can readily conclude that all dimes and circles are dependent upon a given turn rate and a given true airspeed. You should also deduce that by measuring distance of travel along the arc further degrades your position. The aircraft must roll out on the tangent (equal to rollout heading) to the arc, providing that the correct arc was plotted; or more accurately, on the bearing (equal to one-half of the amount of turn) plotted from the start turn position.

Now, if you'll bear with me for awhile, I would like to discuss with you the theories, practical uses, and advantages of the "Chord & Bearing" Method of plotting around a turn. At the conclusion, you will be able to decide which method retains the desired accuracy, flexibility, and convenience to suit your demands.

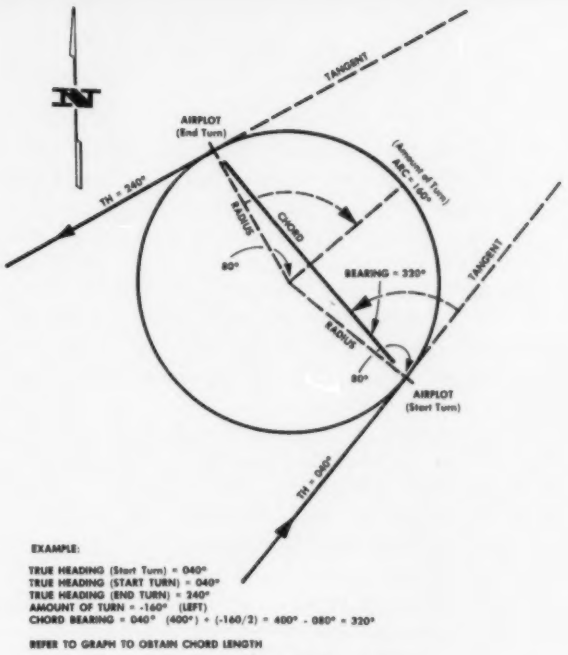


Figure 1

First, let us discuss the theory supporting the "Chord & Bearing" Method. Utilizing airplot navigational techniques, the turn of any aircraft approximates the arc of a true circle equivalent to the amount of turn: i.e., aircraft turns 160 degrees; aircraft flies an arc of 160 degrees. The point of start turn and the point of end turn are tangential points of contact on the true circle. A straight line connecting these points is called a chord. The angle at which the chord joins the tangent is equal to one-half of the angle formed by the adjoining radii (amount of turn) (Figure 1).

The bearing of the chord, plotted to grid north or true north, is dependent upon the aircraft heading before and after the turn. The length of the chord is dependent upon the actual turn rate and the aircraft true airspeed. Now that we have the geometry enthusiasts pacified, a clan of which I am not an intellectual member, let's press on to the practical application.

The first procedure in plotting the chord to the airplot at the initiation of the turn is to compute and plot the bearing. To compute the bearing, you simply take the difference between the initial heading and final heading (amount of turn), divide by two, and apply to the initial heading. If the turn was made to the right, you add to the initial heading; if the turn was made to the left, you subtract from the initial heading. Take the resultant bearing and apply it to the initial airplot. The aircraft will roll out at some point on this bearing, unless you are unfortunate enough to be endowed with a pilot who cannot hold a consistent turn rate. In that case, there is no telling where you will finally roll out. My only suggestion would be to gingerly suggest to your pilot that your navigation will not be benefited by such lack of professionalism. Good Luck!!!!

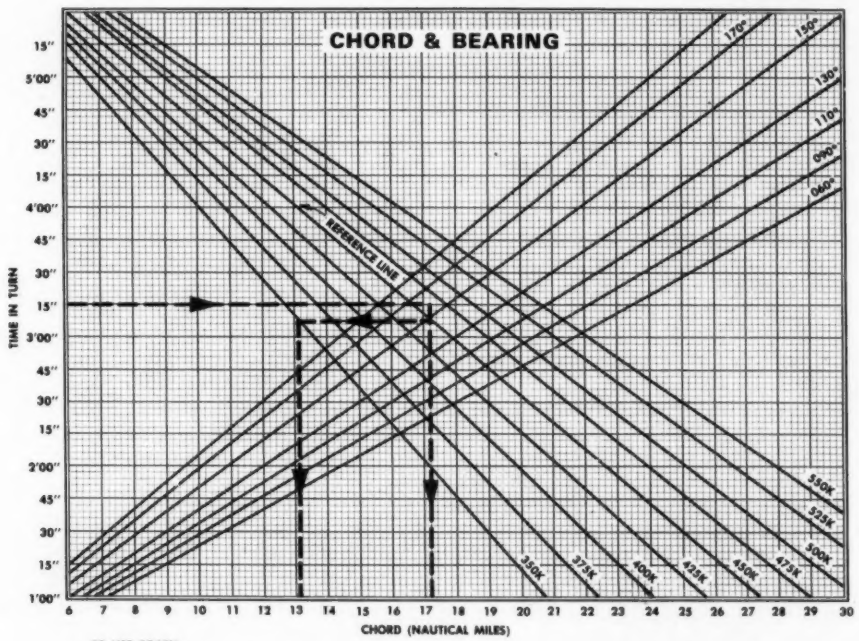
To find the point at which the aircraft rolls out on the bearing (chord), you must first know the amount of time in the turn and aircraft true airspeed. To find the "time in turn," start a stop watch at the commencement of turn and note the elapsed time at rollout. Take this figure along with "true airspeed" and the "amount of turn," enter the "Chord & Bearing" graph (Figure 2). Extract the "chord" and plot to the bearing. The result is the most accurate rollout airplot that you can plot, and with only the aid of a graph.

The advantages of using the "Chord & Bearing" for large turns are its versatility, accuracy, and plotting ease. Other procedures presently used are dependent upon a given turn rate and true airspeed. The "Chord & Bearing" may be applied with a consistent accuracy for any turn rate for any true airspeed, provided the turn rate is somewhat constant, a necessity for any procedure of plotting around turns. If the navigator chooses to adjust the turn rate in order to compensate for timing or track, there will be no loss of accuracy. The navigator may also choose to fly his navigation leg at any true airspeed. Once practiced and understood, this procedure will provide the plotting ease necessary for accurate and versatile navigation.

Another advantage of the "Chord & Bearing" is its ability to be applied to groundplot DR. Once the bearing is found, using true track instead of true heading as above, apply the computed wind values to find the average groundspeed during the turn. Then enter the graph with "time in turn," "amount of turn" (difference in track), and "groundspeed" (instead of true airspeed). Extract the "chord" and plot to the bearing. You now have your rollout DR position.

I realize that it's hard to teach old dogs new tricks. But that piece of philosophy should not restrict our responsibility to the youngsters just beginning to learn the basics and varying techniques of navigation. Exposure is the road to learning and understanding. As instructors and potential instructors, we must expose the students to all possibilities and let them decide the method or technique which suits their ability and personality. Too many times we forget that talents and characters are as varying as the techniques so often employed in navigation. But first, the basics must be applied and understood before any technique can be used effectively. What is the "Chord & Bearing," a basic or technique? That is for you to decide.

Figure 2



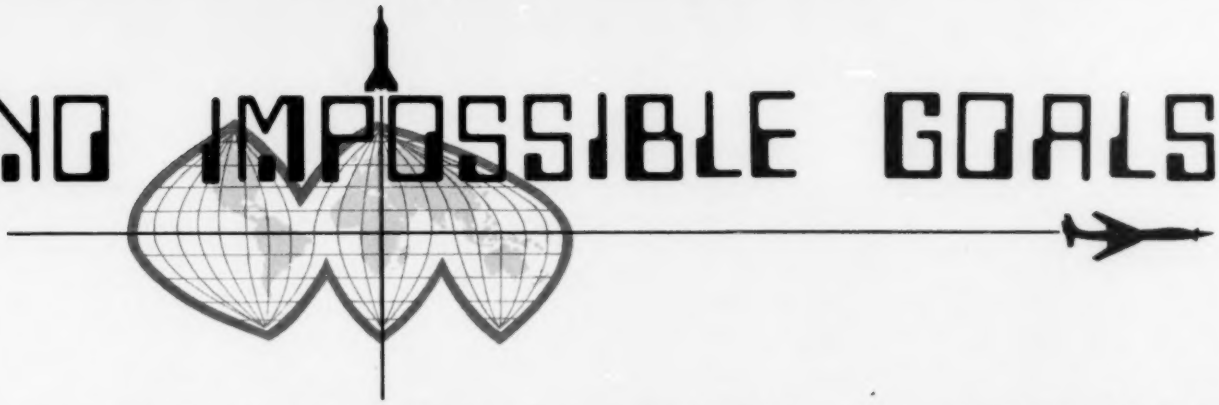
TO USE GRAPH:

1 Enter from left with "Time in Turn."
2 Move horizontally to "Amount of Turn." (If the amount of turn is more than 180°, subtract amount of turn from 360° to obtain proper graph entry.)
3 TAS 450: Move vertically to obtain "Chord" distance.
TAS (other): Move vertically to reference line (450K), horizontally to actual true airspeed, vertically to "Chord" distance.

EXAMPLE: TAS 450K
1 Time in Turn - 3'15"
2 Amount of Turn - 160°
3 Chord equals 17.2

EXAMPLE: TAS 350K
1 Time in Turn - 3'15"
2 Amount of Turn - 160°
3 Chord equals 13.1

NO IMPOSSIBLE GOALS



This article deals with the three most important facets of future strategic navigation—The Mission, The Machine, and The Man. The coming decade and beyond should bring enormous changes in the environment and mechanics of air navigation. To meet the challenges of these changes, a determined effort at understanding the needs and requirements of the future systems must be made *now*.

Recent experience has shown that the strategic mission must serve at least two roles. As long as man retains access to nuclear arsenals, the free world must maintain an ever-ready nuclear response force. Deterrence is the key word. On the other hand, as man retreats from nuclear brinksmanship, he will seek to further his aims with conventional forces. The key word then becomes adaptability. With at least a dual mission, economical use of our resources to effect a flexible posture must be our goal. To meet this goal, we must select the right machinery.

The systems used by future navigators will require increased precision and reliability. Today's equipment, while a great improvement over that of the past, would take on a "Model T" flavor if used in the weapons systems of tomorrow. Indeed, tomorrow's strategic aerospace vehicles will involve advancements in many areas. Future systems may require a bomb-nav system capable of computerized accuracy at multi-mach speeds. Very likely, there will also be a need for a supersonic tanker with an automatic inflight rendezvous capability. Similarly probable is the production of an orbiting navigation system which will provide 100 percent *inflight* positioning accuracy.

The essential elements of future systems would appear to be automatic operation, computerized accuracy, and outstanding reliability. The compression of time and space and the complexity of the equipment will make inflight maintenance, as we now know it, impractical. Dual systems to provide a back-up capability will be vital to insure that the weapon reaches its target. The cost of these future systems will surely be enormous if the requisite standards of accuracy and reliability are to be met. Once given the proper equipment, however, the mission can and will succeed—provided, of course, that we place a properly trained man at the controls.

In the area of strategic navigation, one element will remain unchanged—man will continue to be the primary factor in determining the success or failure of the mission. The man controlling future navigation systems will have to be a highly trained specialist, for economic and spatial limitations will require the merging of many functions. Tomorrow's navigator may need to qualify as a navigator, bombardier, countermeasures expert, and missile operator. To do so, he will most assuredly have to have a working knowledge of engineering and computer programming.

If all systems are working to perfection, he will be no more than a monitor. If a system fails, however, he must become both an analyst and a technician, ready to react instantly. His routine duties must be restricted to essentials so that he will be free to devote his full attention to the key systems. When the normal systems fail, he must be ready to employ "last resort" techniques.

To perform all these acts, he must be one of the most highly trained individuals in the military establishment, and, if he is to meet tomorrow's needs, the training must begin now. Conventional methods meet today's needs, but the future demands a new look, a fresh approach. Education and training will be the keys to success.

For the foreseeable future, our path is clear—we must provide a varied nuclear strike capability with multiple-threat systems that can be converted to a conventional role quickly and economically. Manned systems seem best suited for this role. The equipment provided must be as automated, accurate, and reliable as possible. The man at the controls must be highly trained and skilled. With such a combination, the success of the mission will be assured.

Our nation has a remarkable history of rising above challenges and successfully tackling the unknown. Man is limited only by the scope of his imagination and daring. There are no impossible goals.

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